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Seismic Reflection Survey at Locks and Dams 20, 22, and 24, Upper Mississippi River

by Keith J. Sjostrom, Rodney L. Leist

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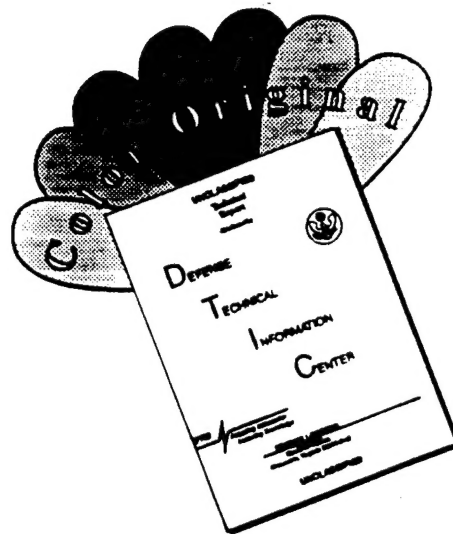
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by Keith J. Sjostrom, Rodney L. Leist

U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

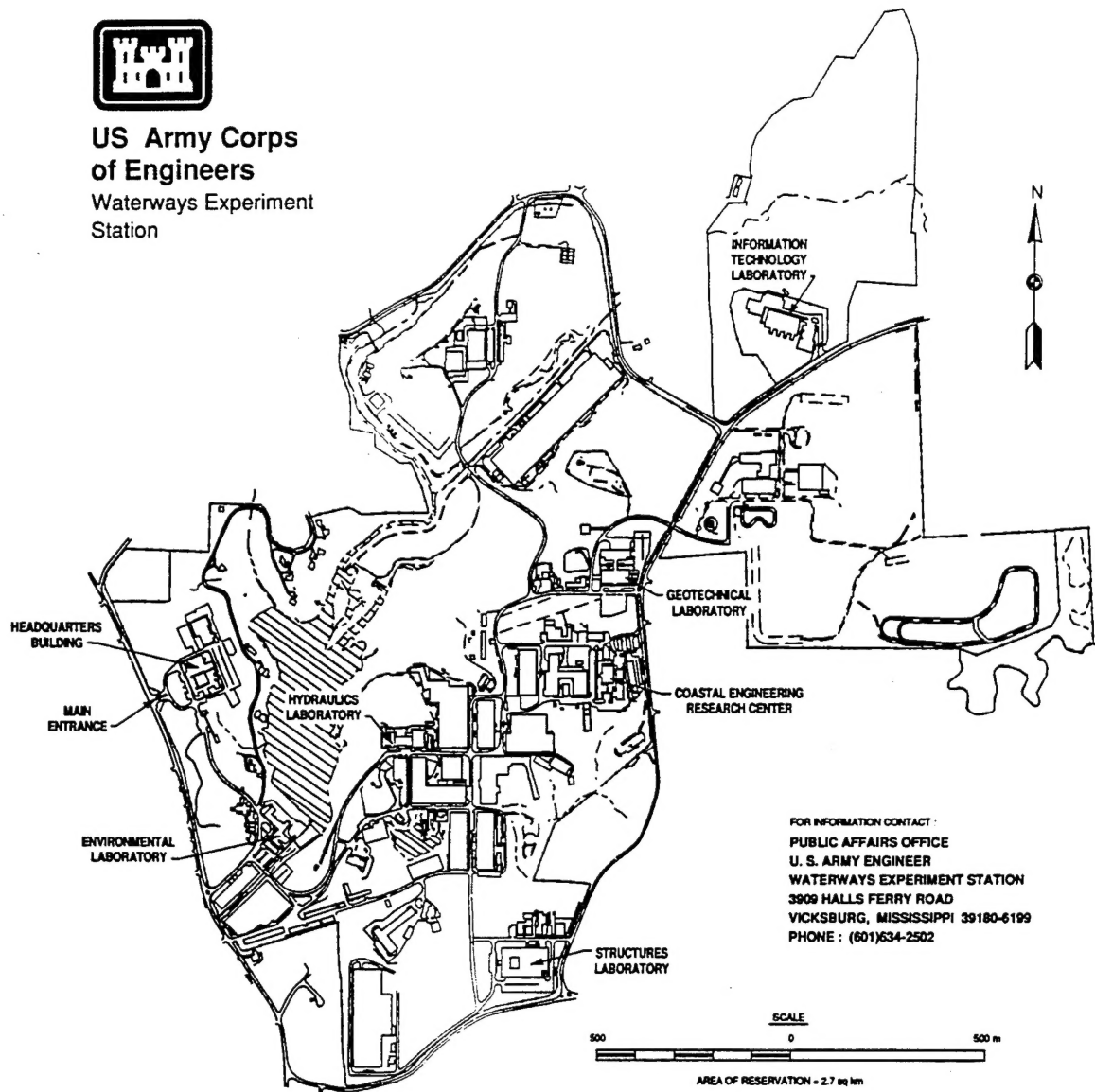
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Preface

A seismic reflection investigation was conducted at Locks and Dams 20, 22, and 24 along the upper Mississippi River by personnel of the Geotechnical Laboratory (GL), U.S. Army Engineer Waterways Experiment Station (WES) during the period 19-26 July 1994. The investigation was performed under sponsorship of the U.S. Army Engineer District, Rock Island (CENCR). The CENCR Project Coordinator was Mr. Randall Kinney.

The overall test program was conducted under the general supervision of Drs. W. F. Marcuson III, Director, GL, and A. G. Franklin, Chief, Earthquake Engineering and Geosciences Division (EEGD). Mr. Keith J. Sjostrom was the principal investigator. This report was prepared by Messrs. Sjostrom and Rodney L. Leist under the supervision of Mr. J. R. Curro, Jr., Chief, Engineering Geophysics Branch, GL. Data acquisition and instrumentation support was provided by Mr. Thomas S. Harmon, Jr., EEGD, GL. Data analysis assistance during this study was provided by Ms. Claire R. Livingston, Computer Services Corporation. Data presentation and graphics support was provided by Ms. Janie M. Vaughan, Hydraulic Structures Division, Hydraulics Laboratory, and Mr. Grady A. Holley, Jr., Applied Research Associates, Inc.

Acknowledgement is made to Messrs. Randall Kinney and Bill Monson, Engineering Division, CENCR, and Mr. Mike Navin, Engineering Division, U.S. Army Engineer District, St. Louis (CELMS), for their assistance during this field study. Captains Dave O'Connell, CELMS, and Ken Brenner, CENCR, are especially appreciated for piloting the WES survey vessel 'Waterways Explorer' during the geophysical survey. Appreciation is also expressed to the lockmasters and personnel at Locks and Dams 20, 22, and 24 for their support, guidance, and assistance.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

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Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
miles (U.S. Statute)	1,609.347	meters
feet per second	0.3048	meters per second

1 Introduction

Background

At the request of the U.S. Army Engineer District, Rock Island (CENCR), the U.S. Army Engineer Waterways Experiment Station (WES) conducted a waterborne seismic reflection survey at Locks and Dams 20, 22, and 24 along the Upper Mississippi River (see Figure 1). Locks and Dams 20, 22, and 24 are located at river mile (RM) 343.2 at Canton, MO, RM 301.2 near Saver-ton, MO, and RM 273.4 at Clarksville, MO, respectively. The locks and dams along the middle and upper Mississippi River are under consideration to be upgraded or replaced in order to provide better navigation along the waterway. Therefore, information concerning the rock surface elevation and sediment thicknesses at each site are necessary in studying and designing the project criteria for this effort.

Purpose and Scope

The objective of the geophysical investigation is to determine the depth to and elevation of the underlying rock units upstream and downstream of each lock and dam structure. The results are intended to supplement previously obtained soil borings by providing continuous profile line coverage of the rock surface throughout each project area and aid in placement of additional borings. The interpreted seismic data will also provide better descriptions of variations in subbottom conditions. Two high resolution subbottom profiling systems were used to meet the primary objectives of the investigation.

Overview of Site Geology

Locks and Dams 20, 22, and 24 are located in a transitional area between the Ozark Uplift and Illinois Basin structural provinces. The near-surface bedrock at these sites is comprised of sedimentary strata of Pennsylvanian and Mississippian age; primarily the Mississippian St. Louis Formation. This formation, as described by the U.S. Army Engineer District, St. Louis (1981),

consists of "... a gray, hard, sublithographic to coarse crystalline, thin to bedded limestone with occasional thin beds of gray shale." Borehole information collected at each site also indicates occurrences of shales and sandstones at the bedrock surface. The elevation of the bedrock surface is highly variable especially near bluffs along the river margins. Regionally, the bedrock strata dip toward the east with a 0.4 degree slope (U.S. Army Engineer District, St. Louis, 1981).

The bedrock structure is overlain by unconsolidated sediments ranging in thickness from 0 to 100 ft. These sediments consist of both glacial and alluvial deposits with materials ranging from clay to boulders. The sediment structure may be identified by at least five specific units which are generally characterized as follows. The deepest sediment regime is an alluvial glacio-fluvial unit containing sand and gravel outwash and glacial lacustrine deposits. Glacial deposits of Illinoian Age overlie the older sediments and consist of a calcareous silt and clay matrix containing sands, gravels, and cobbles. This unit is overlain by Illinoian ice contact deposits of dense sand and gravel. The youngest glacial unit is the Wisconsinian outwash deposits consisting of poorly graded calcareous sands and gravels with cobbles. All, some, or none of these units may be present at the lock and dam sites. Typical river bottom material consists of reworked glacial and alluvial deposits of poorly graded sands and gravels with a few cobbles. Fine-grained material is found at the bottom surface in areas of slack water. More detailed descriptions of the unconsolidated sediment structure are published in U.S. Army Engineer District, St. Louis (1981) and U.S Army Engineer District, Rock Island (1986).

2 Technical Approach

Seismic Reflection Method

Acoustic subbottom reflection data are produced when a source of acoustic energy is deployed just below the water surface and fired. In a homogeneous medium, the acoustic waves extend uniformly in all directions from the source in which the advancing wavefronts are spherical surfaces centered at the source and perpendicular to the direction of propagation. At large distances from the source, the wave fronts may be represented by rays as shown in Figure 2. When the acoustic energy arrives at a boundary between two materials of differing properties and elastic velocities, part of the energy will be reflected back towards the surface and part transmitted downward into the second medium (see Figure 2). Portions of the transmitted energy will also undergo absorption or attenuation in the material while the wavefront propagates through to the next stratigraphic boundary.

The amplitudes of the incident, reflected, and transmitted wave energies vary with respect to the density and velocity of the materials through which the wave energy is propagating. The ratio between the amplitudes of incident and reflected wave energy is called the reflection coefficient (R) and is defined as:

$$R = \sqrt{\frac{A_R}{A_I}}$$

where A_R and A_I are the amplitudes of the reflected and incident wave energy, respectively. Reflected wave energies are detected using hydrophones or piezoelectric transducers which convert changes in water pressure due to the acoustic wavefronts into electrical impulses. The electrical signals are amplified, filtered, and recorded using a shallow seismic, digital data acquisition system. The acoustic sources used for this study are a 3.5 kilo-Hertz (kHz) device, referred to as a 'pinger' system because of the audible sound it makes during operation, and a 0.5 to 2.0 kHz system referred to as a 'boomer' system. In general, higher operating frequencies permit greater resolution of the

near-surface geologic structure but shallower depths of energy penetration depending on the characteristics of the sediment material.

The measured amplitudes of the reflected acoustic waves will vary depending on the angle of incidence, but for normal incidence, the reflection coefficient is also expressed by the equation

$$R = \frac{(Z_{i+1} - Z_i)}{(Z_{i+1} + Z_i)}$$

where Z is the acoustic impedance value of the layer and ' i ' and ' $i+1$ ' identify adjacent stratigraphic layers (see Figure 2). The acoustic impedance of a sediment is defined as the product of the material density (ρ_i) and transmission velocity (V_i) and represents the influence of the material's characteristics on reflected and transmitted wave energy. Specifically,

$$Z_i = \rho_i V_i$$

where ' i ' identifies the appropriate layer. Therefore, when there is a distinct contrast between layers, high amplitude reflections will be generated at the interface. For example, if silty material overlies rock, it is likely that Z_{rock} is much greater than Z_{silt} . Hence, the reflection coefficient R is large and the amplitude of the reflection is higher which means the interface between the silt and rock is easily detectable. However, at a boundary between two materials in which the transmission velocities and densities vary in such a manner that Z_i and Z_{i+1} have similar values, as may exist between layers of sand and gravel over rock, the reflection coefficient is small and the ability to detect the interface diminishes. For a more in depth discussion, refer to Telford (1976).

The depths to the interpreted sediment and rock interfaces are determined by measuring the traveltimes of the transmitted and reflected signals on the amplitude records while taking into account the source/receiver separation and acoustic velocities of the overlying sediment units. The results are adjusted to elevation above mean sea level (MSL) by taking into account daily river level fluctuations above and below the dams. The elevation information is also correlated with the survey vessel positioning data.

Survey Plan and Methodology

Maps showing the location of the seismic reflection survey lines above and below Locks and Dams 20, 22, and 24 are presented in Figures 3, 4, and 5, respectively. Survey lines were performed in areas extending 2,000 ft upstream and 3,000 ft downstream of each lock and dam structure. Lines performed parallel to the channel centerline are nominally spaced 100 ft apart whereas perpendicular lines (cross lines) are spaced approximately 200 or

400 ft apart. The length of each parallel survey line extends a distance of 2,000 ft upstream and 3,000 ft downstream of each dam. Cross lines varied in length depending on the river width. In certain areas, survey line length was also dependent on water depth, water turbulence and flow through the dam, and river traffic. All parallel lines were performed in an upstream direction (against the river current) and the cross lines were conducted from west to east.

The seismic reflection data was produced using two subbottom profiling systems. The first device, a high-resolution 'pinger' system, was mounted on the hull of the survey vessel. The 'pinger' was operated at a tuned frequency of 3.5 kHz and total power of 5.0 kilowatts. The transducers of the source and receiver were separated six feet and each set of transducers were positioned approximately three feet below the water surface. Reflection signatures were digitally recorded in trace lengths of 700 samples with one sample acquired every 24 microseconds. The effective depth of subsurface exploration for this device was nominally 20 to 30 ft below the river bottom surface depending on the characteristics of the bottom and subbottom sediments. The second acoustic system is a high definition 'boomer' system and hydrophone which were towed approximately 70 ft behind the survey vessel during the investigation. The 'boomer' provided an output frequency range of 0.5 to 2.0 kHz. A total trace length of 700 samples was used during data acquisition with samples collected every 52 microseconds. An approximate depth of exploration of 50 to 70 ft below the bottom surface was provided using the 'boomer' system.

Positioning information for each survey line was provided using differential GPS and recorded concurrently during seismic data acquisition. Precision bathymetric data are also simultaneously collected during each survey. River bottom elevations, derived from the water depth information, are referenced to Mean Sea Level (MSL) for each lock and dam facility using daily pool level information and the source/receiver transducer geometry. Pool and tailwater levels at the time of the survey for each lock and dam facility are listed in Table 1.

3 Data Analysis and Results

Data Analysis and Presentation

Data acquired and results determined during the seismic reflection investigation at Locks and Dams 20, 22, and 24 are presented in several profiles, plots, and tables. Continuous subbottom profiles of the acoustic reflection amplitudes along each survey line illustrate detected sediment and rock interfaces. Copies of the amplitude cross-sections were sent to the CENCR project engineer in September 1994. The positioning coordinates, water depths, and river bottom elevations are tabulated with respect to every third seismic data file in Appendices A through F for both the 'pinger' and 'boomer' subbottom profiling systems. The depths to detected rock interfaces are determined directly from the amplitude cross-sections by measuring the two-way traveltime of the seismic reflection signals and multiplying by 4,900 ft/sec; the propagation velocity of the acoustic pulse in the water and overlying sediments. The interpreted rock elevations and positioning coordinates are used to produce two-dimensional contour maps of the rock surface. The contour plots are overlain on schematic representations of each lock and dam site to aid interpretation of the results. Contour maps of the river bottom elevation at the time of the survey are also provided.

Limitations in interpretation

Despite the simplistic overview of the basic seismic reflection principles discussed earlier, the analysis and interpretation of seismic reflection data requires great skill. Besides the subjectivity involved in selecting reflection horizons from the amplitude records, other factors such as outside acoustic noise, complex sediment geometries, and organically-rich sediments may also complicate interpretation. Two important factors as related to this study are: (1) frequent lithologic changes in the near-surface sediments in which numerous reflection horizons exist and (2) surface and subsurface irregularities and steeply dipping rock interfaces which cause the reflected signals to scatter away from the receiver such that reflected events may have anomalously low amplitudes or be completely masked. However, throughout most of the survey, favorable conditions existed such that distinct reflections can be identified

and information regarding the depth to and elevation of sediment and rock interfaces can be derived.

The depth to rock interpretations are measured from data collected with a remote sensing technique and should not be considered absolute measurements. As with any geophysical technique, there are limitations involved with the seismic reflection technique. Some of these limitations are outlined below as described by McGee et al.(1995).

Signal-to-noise ratio. The ability of this technique to accurately detect subbottom layers is a function of the data quality. Data having a low signal-to-noise ratio will produce poor quality results or no results at all. The data quality at each lock and dam site was generally good. However, there were areas of poor signal-to-noise data caused by water turbulence near the dam and boat motor noise during vessel maneuvering and turning. A portion of a seismic reflection record, collected downstream of Lock and Dam 24, is presented in Figure 6 and illustrates the poor data quality caused by water turbulence downstream of the dams.

Layer detection and resolution. Unique sediment and rock interfaces can be detected only when a difference in impedance exists between materials. Gradual changes in material type, e.g. fractured rock overlying competent rock, may not result in an impedance differential large enough to produce a distinct reflection.

Vertical resolution of sediment units and depth of exploration are primarily dependent on the frequency of the acoustic wave. As stated earlier, higher operating frequencies allow better resolution of the subbottom layers but shallower depths of energy penetration depending on the characteristics of the bottom and subbottom material. In sediments having high attenuation rates such as sands or gravels, higher frequencies are dissipated at a greater rate than low frequency signals and, therefore, layer recognition is further degraded. Data enhancement algorithms, such as full wave rectification, are typically used improve the signal-to-noise ratio and interface detection.

Multiple reflections. Multiple reflections are one of the primary causes of data quality degradation in shallow marine seismic measurements. The most common multiples detected are due to the acoustic wave being reflected back and forth between the air-water and water-sediment interfaces. As illustrated in Figure 10, the multiple reflection is a copy of the bottom surface reflector but located at a depth twice that of the water depth. Multiple reflections typically mask the reflections from other subbottom interfaces or, depending on water depth and the reflection coefficient at the water/bottom surface interface, completely saturate the record such that no interfaces may be detected. The direct

wave between the acoustic source of the 'boomer' system and receiver hydrophone array is also indicated at the top of Figure 10.

Depth Determination. Determining a depth to an interface requires measurement of the traveltimes of the transmitted and reflected wave while taking into account the acoustic velocities within the overlying materials. For this study, all interface depths are based on an average acoustic velocity of 4,900 ft/sec for the entire water and sediment column. The accuracy of these results is also somewhat restricted because of the specific pulse lengths of the acoustic signals. The 'pinger' and 'boomer' devices have well-defined acoustic pulse lengths and are able to resolve an interface to within approximately ± 2.5 and ± 5.0 ft, respectively. The acoustic pulse wavelets are graphically illustrated in Figures 9 and 11 for the 'boomer' and 'pinger' sources, respectively. For the depth to rock measurements, an error bound of ± 2.0 ft should be allowed. The error bounds of the measured bottom depths are less than ± 0.5 ft because the acoustic device used operates at a much greater frequency, namely 200 kHz.

Data presentation. The measured bottom surface and interpreted rock surface elevations are presented in 2-D contour plots. The plots are generated using a geostatistical method called kriging which is an unbiased estimator that has minimal estimation errors. The technique spatially averages the data over a specified radius and, therefore, may smooth some of the elevation values.

Existing Borehole Information

Prior to and during the construction phases of each lock and dam facility in the early to mid-1930's, exploratory borings were completed to determine the depth to the bedrock interface. The approximate locations of a representative number of borings at each site are illustrated in Figures 8, 14, and 20 for Locks and Dams 20, 22, and 24, respectively. At each facility, borings are concentrated near the lock and along the dam structure. No measured rock depth information is available away from the structures to assist in ground truth correlation. A summary of rock elevation information determined from the borings shown are outlined in Tables 2, 3, and 4 for Locks and Dams 20, 22, and 24, respectively.

Results of Seismic Reflection Survey

Lock and Dam 20

Lock and Dam 20 is located at RM 343.2 on the Upper Mississippi River at Canton, MO. A total of 42 seismic reflection survey lines were performed at the lock and dam site (see Figure 3). Twenty-two (22) surveys are situated upstream of the lock and dam with 15 lines performed parallel to the river channel. Downstream of the lock and dam, 20 seismic survey lines were performed with 13 lines conducted parallel to the river channel. Data quality was good except just below the dam where turbulent water created noise in the seismic records. Plan maps illustrating the river bottom and interpreted rock elevations are presented in Figures 7 and 8, respectively.

The elevation of the river bottom upstream of the dam varies from 441 ft MSL near the lock structure to 467 ft MSL. The water depth values are greatest along the dam structure with the deepest point located near the gates closest to the lock facility. Two channels having bottom elevations less than 457.5 ft MSL trend along the western and eastern edges of the site as shown in Figure 7. These areas of deeper water are likely caused by the flow patterns and erosional/depositional characteristics of the river due to the structure and the operational history of the facility. The central portion of the survey area upstream of the dam has bottom elevation values greater than 460 ft MSL. The river bottom elevations computed downstream of the dam range from 431 ft MSL near the dam to 460 ft MSL along the river margins. The bottom elevation is typically less than 455 ft MSL along the centerline of the river as shown in Figure 7 with elevation values increasing towards each riverbank. The deepest water is along the gates nearest to the lock facility. Bottom elevation values at the upstream and downstream approaches to the lock are greater than 457.5 ft MSL. The water level elevation upstream and downstream of the dam at the time of the survey was 479.0 and 476.4 ft MSL, respectively.

Interpreted rock elevation values at the approaches to the lock are greater than 455 ft MSL as illustrated in the contour plot in Figure 8. North and south of the lock, the bedrock elevation remains fairly constant with values ranging from 455 to 460 ft MSL along the western edge of the study area. Comparing the acoustically derived rock elevation information to values measured from existing borings, the results indicate good correlation both upstream and downstream of the lock. The boring locations are shown in Figure 8 with the measured elevations summarized in Table 2. Within a few hundred feet east of the lock, the depth to rock increases rapidly until the bedrock surface is no longer detected in any of the existing borings. Seismic data collected with the 'boomer' system along survey line No. 54, performed perpendicular to the river channel, is shown in Figure 9 and illustrates the rapidly increasing depth to the rock surface. The lock is at the left hand side of the figure where the bedrock is detected at the bottom surface. The interpreted rock interface is poorly defined because of the steeply dipping

reflection horizon and acoustic noise caused by turbulent water below the dam. From a location near the center of the river channel and to the eastern riverbank, there are no reflection interfaces detected upstream or downstream of the dam which are indicative of rock. Therefore, the bedrock elevation is likely lower than 420 ft MSL across the central and eastern part of the river. Near the eastern river edge, another interface is detected as shown in Figure 9. This interface dips steeply towards the west and correlates with a compacted sand, gravel, and loose rock zone indicated in borings 19 and 20 along the eastern side of the dam. This interface is also detected along survey line No. 44 performed parallel with the river channel upstream of the dam as illustrated in Figure 10.

The near-surface alluvial sediments consist primarily of silts, sands, gravels, and rock fragments. Bedding planes, zones of gravels and cobbles, former channel bottoms, and other sediment facies are detected within the study area. The seismic data illustrated in Figures 11 and 12 was collected with the 'pinger' along survey lines No. 12 (downstream of the dam) and No. 29 (upstream of the dam), respectively, and illustrate some of the interfaces and reflection horizons in the near-surface sediments. The first interface detected below the river bottom surface along survey line No. 12 (see Figure 11) may represent the river bottom surface prior to the 1993 flood.

Lock and Dam 22

Lock and Dam 22 is located near the town of Saverton, MO at RM 301.2 along the Upper Mississippi River. Forty-three (43) seismic reflection surveys were conducted at Lock and Dam 22 as shown in Figure 4. Twenty-one (21) seismic lines were performed downstream of the lock and dam with 15 lines performed parallel to the river channel. Upstream of the lock and dam, 22 surveys were conducted with 17 lines traversing parallel to the river channel. No surveys were conducted along the northeastern side of the river because of shallow water. Data quality was good along all lines except in those areas just below the dam where turbulent water produced noise in the seismic records. Plan maps illustrating the river bottom and interpreted rock elevations are presented in Figures 13 and 14, respectively.

River bottom elevations upstream of the dam vary from 427 ft MSL at the dam to approximately 448 ft MSL at the upstream edge of the study area. Water depth values are greatest along the dam structure with the deepest point located near the abutment between the dam and concrete dike. The river bottom geometry is similar to that found above Lock and Dam 20 where two channel features trend diagonally away from the dam towards the northeastern and northwestern river banks and have bottom elevation values lower than 440 ft MSL. The central portion of the survey area has bottom elevation values higher than 440 ft MSL as illustrated in Figure 13. River bottom elevations measured downstream of the lock and dam facility range from approximately 427 ft MSL near the dam to 440 ft MSL near the river margins

(see Figure 13). Bottom elevations are typically lower than 435 ft MSL along the center-line of the river. The deepest water downstream of the dam is also detected near the abutment between the dam and concrete dike. The water level elevation upstream and downstream of the dam at the time of the survey was 459.5 and 455.0 ft MSL, respectively.

The contour map illustrating the interpreted rock surface elevation at Lock and Dam 22 is presented in Figure 14. The elevation values of the interpreted rock surface are greatest near the lock facility and gradually slope to lower values towards the northeast. Rock elevation values at the lock are higher than 435 ft MSL. Away from the lock facility, the rock elevation is lower than 415 ft MSL upstream of the dam and below 425 ft MSL downstream. The northeastward sloping rock interface is indicated on the seismic record shown in Figure 15. The data was collected with the 'boomer' along survey line No. 67 upstream of the lock and dam. The bedrock surface upstream of the dam is shown in Figures 16 and 17 where seismic data was collected with both the 'pinger' and 'boomer', respectively. This data was collected parallel to the river channel along a portion of survey line No. 33. The amount of sediment overlying the bedrock upstream of the dam varies from 5 to 30 ft and consists primarily of silts and sands. Bedding planes, zones of gravels and cobbles, and other sediment facies are also detected in the near-surface material. Downstream of the dam, sediment thickness varies from 0 to 10 ft. The varying thickness of the overlying sediment is best illustrated by the sub-bottom data collected along survey line No. 10 shown in Figure 18. The rock surface emerges from beneath a mound of sandy sediment and is situated close to the current river bottom surface as indicated at the right side of the figure. The detected mound of sediment may be a depositional feature formed following the 1993 flood and overlies the pre-flood river bottom surface.

At the lock facility and along the dam, rock elevation information from the existing borings correlate well with the interpreted elevation values. The approximate locations of the borings are presented on the interpreted rock elevation contour map shown in Figure 14 with the measured rock elevation values listed in Table 3. Referring to Table 3 and the contour map in Figure 14, interpreted rock elevation values along the dam agree to within a foot of the measured rock elevation values. Closer to the lock structure, the difference between the interpreted values and measured elevations varies from 1 to 3 ft. As an example, measured rock elevation values at borings 16, 19, and 9 are 429.5, 435.6, and 436.2 ft MSL, respectively. The respective rock elevations interpreted from the seismic data at these locations are approximately 433.0, 434.0, and 434.5 ft MSL.

Lock and Dam 24

Lock and Dam 24 is located at RM 273.4 at Clarksville, MO. A total of 49 seismic reflection surveys were performed at the project area as indicated in Figure 5. Twenty-two (22) seismic lines were performed upstream of the dam with 16 lines performed parallel to the river channel. No surveys were

conducted along the northeastern side of the river because of shallow water. Downstream of the lock and dam, seismic data was collected along 27 surveys with 19 lines conducted parallel to the river channel. In the upstream pool, data quality was good along all survey lines. Between the dam and a point approximately 500 ft downstream of the dam, data quality was fair to poor because acoustic noise generated by water turbulence (refer back to Figure 6) and excessive boat engine noise contaminated the data records. Further downstream of the dam, data quality was fair to good. Plan maps illustrating the river bottom and interpreted rock elevations are presented in Figures 19 and 20, respectively.

River bottom elevation values upstream of the dam vary from 412 ft MSL at the dam to higher than 430 ft MSL along the southwest river bank (see Figure 19). The water level elevation upstream of the dam at the time of the survey was 447.5 ft MSL. Water depth values are greatest along the dam structure with depths exceeding 30 ft at locations nearest the lock facility. River bottom elevation values along the main portion of the river channel gradually increase upstream of the dam and reach an average elevation of 425 ft MSL at the upstream limit of the study area. River bottom elevation values measured downstream of the lock and dam facility range from approximately 390 ft MSL near the dam to higher than 425 ft MSL near the river margins (see Figure 19). Water depths are approximately 40 ft along the base of the dam with the greatest depths detected downstream of the gates farthest from the lock facility. Downstream of the dam, bottom elevation values are typically lower than 417.5 ft MSL along the channel centerline. The water level elevation downstream of the dam at the time of the survey was 441.0 ft MSL.

The elevation of the interpreted rock surface at Lock and Dam 24 is represented by the contour lines shown in Figure 20. The rock elevation values are greatest near the lock facility and dramatically decrease to lower elevations within a few hundred feet northeast of the lock. Further along the dam, the elevation values level off and gradually slope downward towards the northeast. Rock elevations at the upstream entrance to the lock are approximately 425 ft MSL whereas near the downstream entrance, rock elevation values are higher than 405 ft MSL. Delineation of the rock surface was hindered by poor data quality, limited energy penetration, and poor resolution of the steeply dipping rock interface near the lock. Seismic data collected along survey line No. 4 (see the right side of Figure 21) downstream of the lock illustrates the difficulty in detecting the rock interface. In addition, competent river bottom sediments such as gravels or rock fragments, as sampled in many nearby cores, may also diminish the resolution of the underlying rock surface as demonstrated in Figure 22.

Away from the lock facility and upstream of the dam, the rock surface has a more gradual slope and is better defined. Interpreted rock elevation values range from approximately 385 ft MSL near the lock to lower than 375 ft MSL towards the north-northeast side of the study area (see Figure 20). The

northeastward sloping rock interface is indicated on the seismic records shown in Figures 23 and 24 for 'boomer' data collected along survey lines No. 35 and No. 75, respectively. Downstream of the dam, rock surface elevation values range from 380 to 385 ft MSL over most of the study area as shown in Figure 20. Interpreted rock elevation values begin to increase rapidly near the southwestern river margin. Portions of the 'boomer' seismic record collected along survey lines No. 3 and No. 4 are presented in Figures 25 and 21, respectively, and illustrate the interpreted rock interfaces for both the limestone and overlying shale units.

The measured rock elevation values from borings drilled along the gates of the dam correlate well with the interpreted elevations from the seismic data. The approximate locations of representative borings are presented on the interpreted rock elevation contour map shown in Figure 20. Measured rock elevation values are listed in Table 4. As a comparison between measured and interpreted rock elevations, the measured rock elevation values from borings 78 and 84 are 382.0 and 381.0 ft MSL, respectively. Referring to Figure 20, the interpreted elevations from the seismic data are approximately 384.5 and 380.0 for the same locations. Although the correlation between the measured and interpreted rock elevation values along the dam are good, the correlation between the elevation results in and around the lock are much poorer. The difference between interpreted values and measured elevations varies from 1 to 10 ft. As an example, the measured rock surface elevations at borings 15, 66, and 53 are 384.8, 384.0, and 401.2 ft MSL, respectively. The respective rock elevation values interpreted from the seismic data at these locations (see Figure 20) are approximately 392.0, 387.0, and 402.0 ft MSL. The differences between these values may be attributed to poor data quality and poor resolution of the rock surface as per the limitations discussed earlier in the text. Also, for example, the slope of the rock surface near boring 15 makes the location of the boring critical for comparison.

The interpreted thickness of sediment overlying the bedrock surface upstream of the dam varies from 30 to 50 ft whereas approximately 15 to 40 ft of alluvial material overlies the rock surface below the dam. The thickness of this material generally increases towards the channel margins. The unconsolidated sediments consist of silts, sands, gravels, and rock fragments with bedding planes, lenses, and other sediment facies detected in the near-surface material. Seismic data collected with the 'pinger' along survey lines No. 3 (downstream of the dam) and No. 30 (upstream of the dam), see Figures 26 and 27, respectively, illustrate the numerous interfaces and reflection horizons in the near-surface sediments. Some of the interfaces may represent the river bottom prior to the 1993 flood.

4 Survey Summary

A high-resolution, seismic reflection survey was performed at Locks and Dams 20, 22, and 24 along the Upper Mississippi River to determine the rock surface elevation at each facility. Analysis of the seismic data yielded interpreted rock surface elevation values upstream and downstream of each lock and dam. Rock surface elevations, presented in two-dimensional contour plots, are compared to borehole information to provide better analysis of the rock surface. Bathymetry data collected during the seismic survey is also presented in contour plots in order to investigate the geometry of the river bottom at the time of the survey. The contour maps are displayed on schematic diagrams of each project area.

At Lock and Dam 20, the bedrock surface is only detected near the lock facility. The elevation values north and south of the approaches to the lock are greater than 455 ft MSL which correlates well with measured values from existing core locations. A few hundred feet east of the lock, the depth to rock increases rapidly towards the east until it is no longer detected by the seismic methods or existing borings. The elevation of the bedrock surface is lower than 420 ft MSL across the remainder of the site. Along the eastern side of the river, east of E 124,000 grid line, a dipping horizon comprised of compacted sand and gravel is detected. Bedding planes and smaller zones of sand and gravel are also detected throughout the near-surface sediments.

At Lock and Dam 22, the elevation values of the interpreted rock surface are higher near the lock facility and gradually slope towards the northeast. Rock elevation values at the lock are greater than 435 ft MSL. Away from the lock, rock elevation values are less than 415 ft MSL upstream of the dam and lower than 422 ft MSL downstream. Along the dam, the interpreted rock elevation values agree to within a foot of measured values from existing boring information. Closer to the lock structure, the difference between the interpreted values and measured elevations varies from 1 to 3 ft. The amount of sediment overlying the bedrock upstream of the dam varies from 5 to 30 ft and consists primarily of silts and sands. Bedding planes, zones of gravels and cobbles, and other sediment facies are also detected in the near-surface material. Downstream of the dam, sediment thickness varies from 0 to 10 ft near channel centerline with greater thicknesses detected along the channel margins.

At Lock and Dam 24, the elevation values of the interpreted rock surface are higher near the lock facility and dramatically decrease to lower elevations within a few hundred feet northeast of the lock. Along the dam structure, the interpreted rock surface elevation gradually slopes downward towards the northeast. Upstream of the dam, the rock surface has a gradual slope with interpreted elevation values ranging from approximately 385 ft MSL near the lock to less than 375 ft MSL towards the north-northeast side of the study area. Downstream of the dam, the rock surface elevation ranges from 380 to 385 ft MSL over most of the study area. Measured rock elevations from cores along the gates of the dam correlate well with interpreted values from seismic data with differences of 1 to 3 ft. Rock elevation values increase rapidly near the lock and along the southwestern river margin. Rock elevations at the upstream entrance to the lock are approximately 425 ft MSL whereas near the downstream entrance, elevation values are higher than 405 ft MSL. However, delineation of the rock surface was hindered by poor data quality and limited resolution of the steeply dipping rock interface. The correlation between the measured and interpreted elevation results in and around the lock is fair. However, comparisons near the lock are dependent on the position of the existing borings over the steeply sloping rock surface. The difference between interpreted values and measured elevations varies from 1 to 10 ft. The interpreted thickness of sediment overlying the bedrock surface upstream of the dam varies from 30 to 50 ft whereas approximately 15 to 40 ft of alluvial material overlies the rock surface below the dam. Little to no sediment overlies the rock surface near the lock.

The near-surface alluvial sediments at each site are comprised primarily of silts, sands, gravels, cobbles, and rock fragments. Bedding planes, zones of gravels and cobbles, former channel bottoms, sand bars, and other sediment facies are commonly detected in the near-surface material within each study area. In certain areas, as pointed out in the text, interfaces near the bottom surface may represent the river bottom surface prior to the 1993 flood.

Analysis of the seismic information provides continuous profiles of the rock surface and illustrates variations in the bottom and subbottom sediments. Elevation values computed from the seismic records depict the extent and depth of the river bottom, rock surface, and other reflection horizons. Rock elevations at each facility will provide data to support the planning phases for replacement or modernization of the locks and dams.

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- Telford, W. M., Geldart, L. P., Sheriff, R. E., and Keys, D. A. (1976). *Applied Geophysics*. Cambridge University Press, New York.
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Table 1**Average Water Level Elevations, Upper Mississippi River**

	Pool Elevation (ft, MSL)	Tailwater Elevation (ft, MSL)
Lock and Dam 20	479.0	476.4
Lock and Dam 22	459.5	455.0
Lock and Dam 24	447.5	441.0

Table 2
Summary of Borehole Information Lock and Dam 20, Upper
Mississippi River

Core	Easting ¹	Northing ¹	River Bottom Elevation, ft	Rock Elevation, ft
6	123265	1269141	470.4	437.5
7	123286	1269142	465.0	429.3
8	123309	1269144	459.3	426.0
9	123255	1269033	471.5	440.5
10	123286	1269034	465.7	434.1
11	123315	1269038	457.5	425.2
15 ²	123633	1269110	456.0	---
16 ²	124045	1269118	466.8	---
17 ²	124352	1269145	466.5	---
18 ²	124684	1269163	460.7	---
19 ²	125091	1269178	470.5	---
20 ²	125391	1269195	481.5	---
17	122903	1269939	459.3	457.3
18	122830	1270049	464.0	456.4
19	122815	1270148	464.3	459.2
20	123157	1268055	461.6	461.6
21	123044	1268355	464.9	464.9
32	123083	1268949	459.3	459.3
37	123018	1269558	458.0	458.0
38	122986	1269855	458.2	458.2
39	122958	1270154	458.3	455.8
40	122929	1270448	458.8	458.8
41	123193	1268336	458.9	458.9
42	123183	1268540	458.0	458.0
43	123230	1268671	455.3	455.3
45	123203	1268975	453.7	453.7
48	123192	1269243	454.5	454.5
52	123195	1269461	454.3	445.1
55	123176	1269648	453.7	437.0
56	123120	1269868	455.3	444.3

¹ Approximate coordinates.

² Cores located along dam structure.

Table 3
Summary of Borehole Information Lock and Dam 22, Upper
Mississippi River

Core	Easting ¹	Northing ¹	River Bottom Elevation, ft	Rock Elevation, ft
1	194450	1083838	440.7	433.6
9	195912	1081984	437.0	436.2
10	194929	1083454	432.4	431.0
12	195273	1082977	437.9	437.6
14	195627	1082498	437.8	437.0
15	194855	1083761	429.6	427.0
16	195036	1083530	430.3	429.5
17	195221	1083296	434.0	434.0
18	195404	1083070	434.6	434.6
19	195587	1082836	435.6	435.6
20	195768	1082598	433.8	433.4
21	195951	1082368	433.3	432.2
24	195516	1083162	433.5	433.0
27	195587	1083365	437.6	430.2
30	195804	1083379	441.2	428.5
33	195881	1083578	440.0	425.8
36	196102	1083591	---	approximately 423.0
47	195389	1083310	433.2	432.4
48	195704	1083539	442.0	427.4
50	196119	1083803	444.4	421.1
52	196278	1083918	446.7	420.2
54	196442	1084040	447.8	418.7
56	196596	1084156	447.9	417.4
57	196837	1084318	447.7	414.7
58	197070	1084493	447.6	412.5
59	197309	1084673	443.0	405.2
60	197555	1084848	440.9	407.8
61	197797	1085025	467.6	408.1
¹ Approximate coordinates.				

Table 4
Summary of Borehole Information Lock and Dam 24, Upper
Mississippi River

Core	Easting ¹	Northing ¹	River Bottom Elevation, ft	Rock Elevation, ft
1	384274	1290186	427.3	420.6
2	384535	1289976	431.2	424.0
3	384707	1289825	434.0	427.4
9	384813	1289927	408.1	397.1
13	384753	1290187	414.0	383.4
14	384917	1290032	416.4	383.2
15	385178	1289836	415.8	384.8
16	385372	1289645	416.2	386.8
36	385027	1289715	422.5	422.5
37	385249	1289517	423.9	421.3
40	385322	1289592	432.4	412.1
43	385438	1289537	417.0	390.2
50	386043	1288633	427.2	415.8
52	385858	1288895	424.7	410.8
53	386096	1288690	422.6	401.2
56	385571	1289203	423.4	420.7
57	385772	1289031	423.2	406.7
58	386042	1288820	422.7	392.2
59	384388	1290291	420.1	392.0
60	384643	1290080	419.9	396.5
61	385536	1289320	420.3	405.8
62	385948	1288993	421.6	394.1
65	385633	1289421	417.6	386.1
66	385821	1289271	419.1	384.0
67	386042	1289092	419.4	384.1
68	385725	1289171	421.5	398.6
76	385393	1289832	---	384.0
78	385538	1290016	---	382.0
80	385684	1290200	---	381.0
82	385825	1290383	---	381.0
84	385970	1290566	---	381.0
86	386116	1290750	---	375.0

¹ Approximate coordinates.



Figure 1. Location of Locks and Dams 20, 22, and 24, Upper Mississippi River

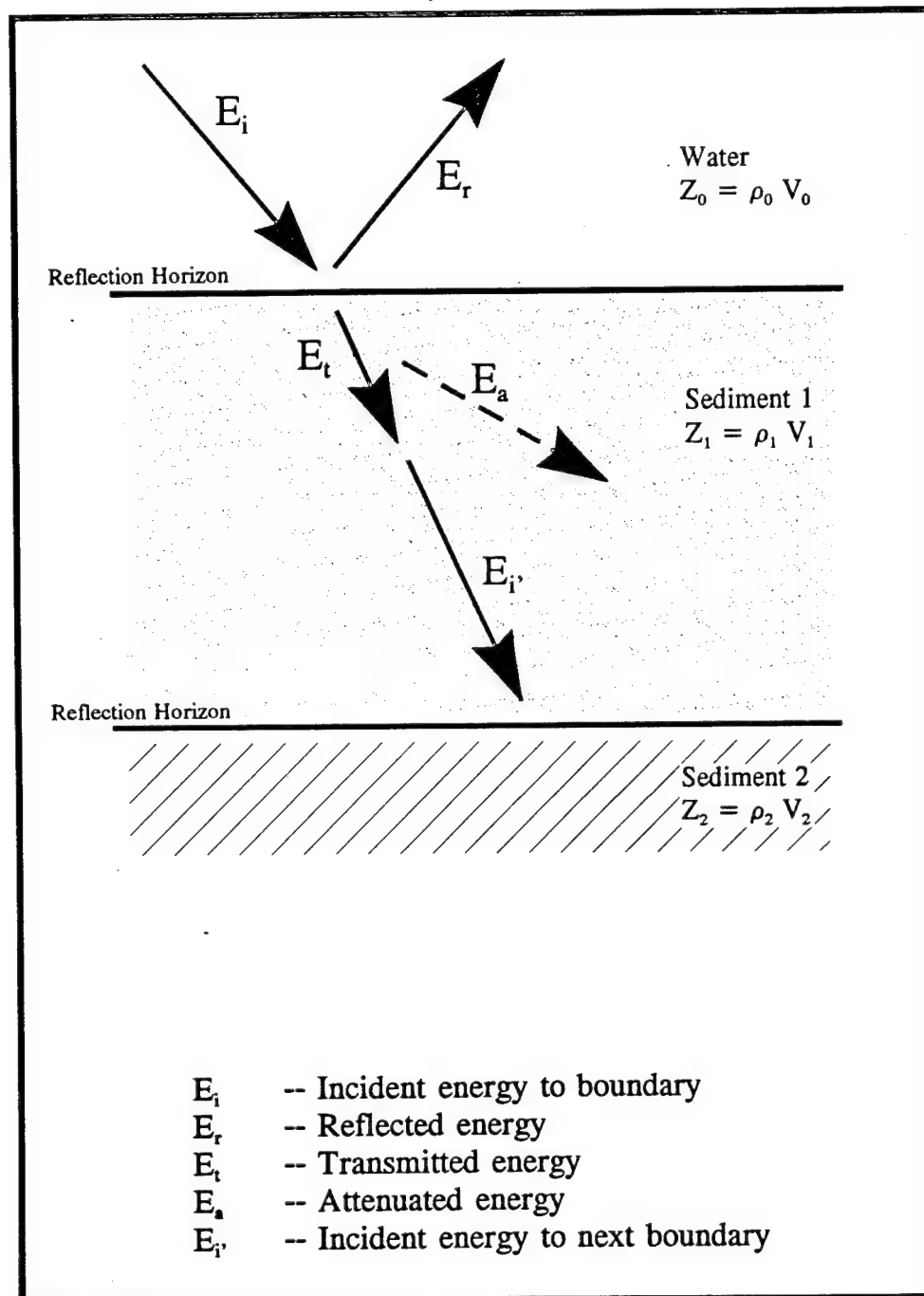


Figure 2. Energy path schematic

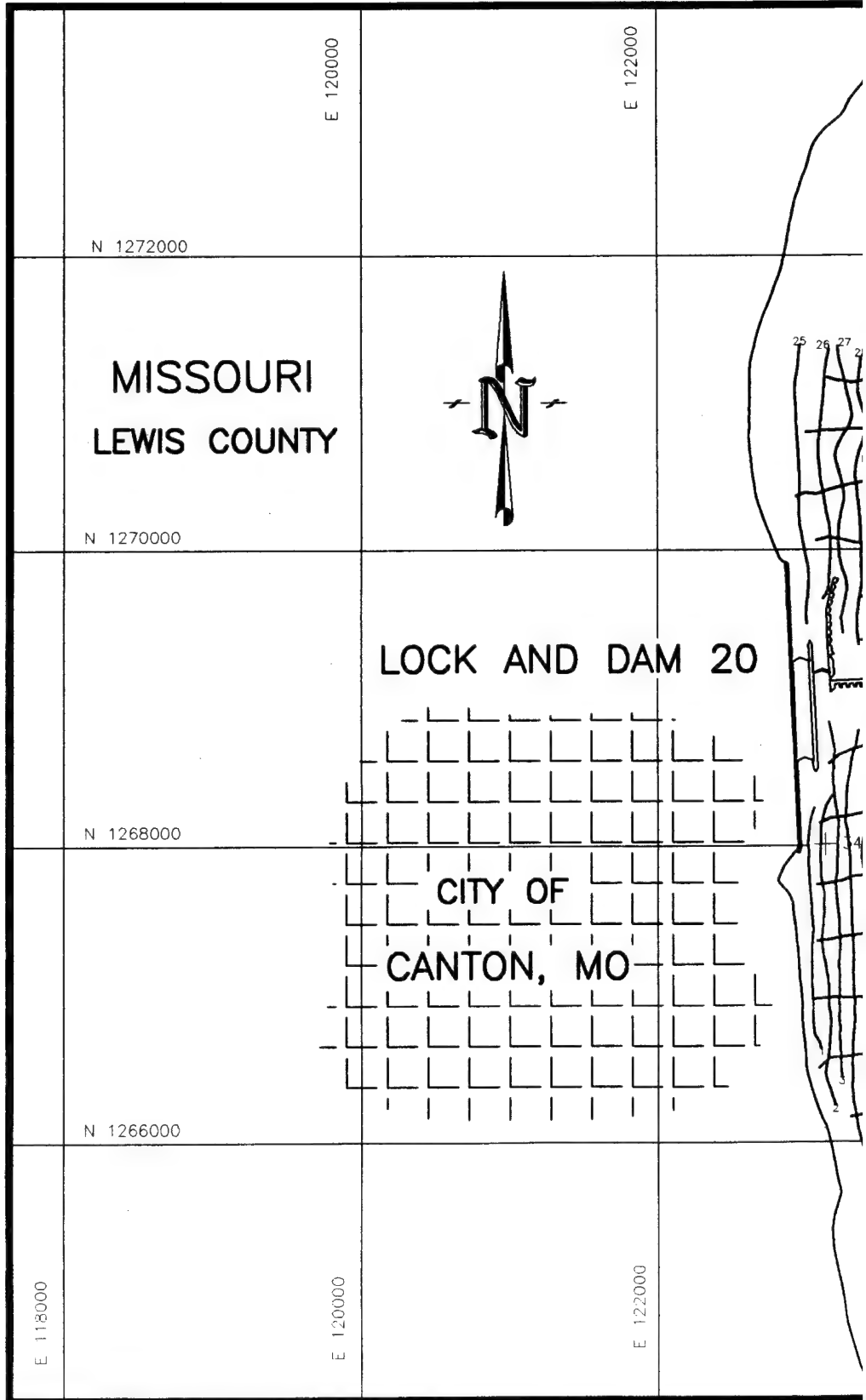
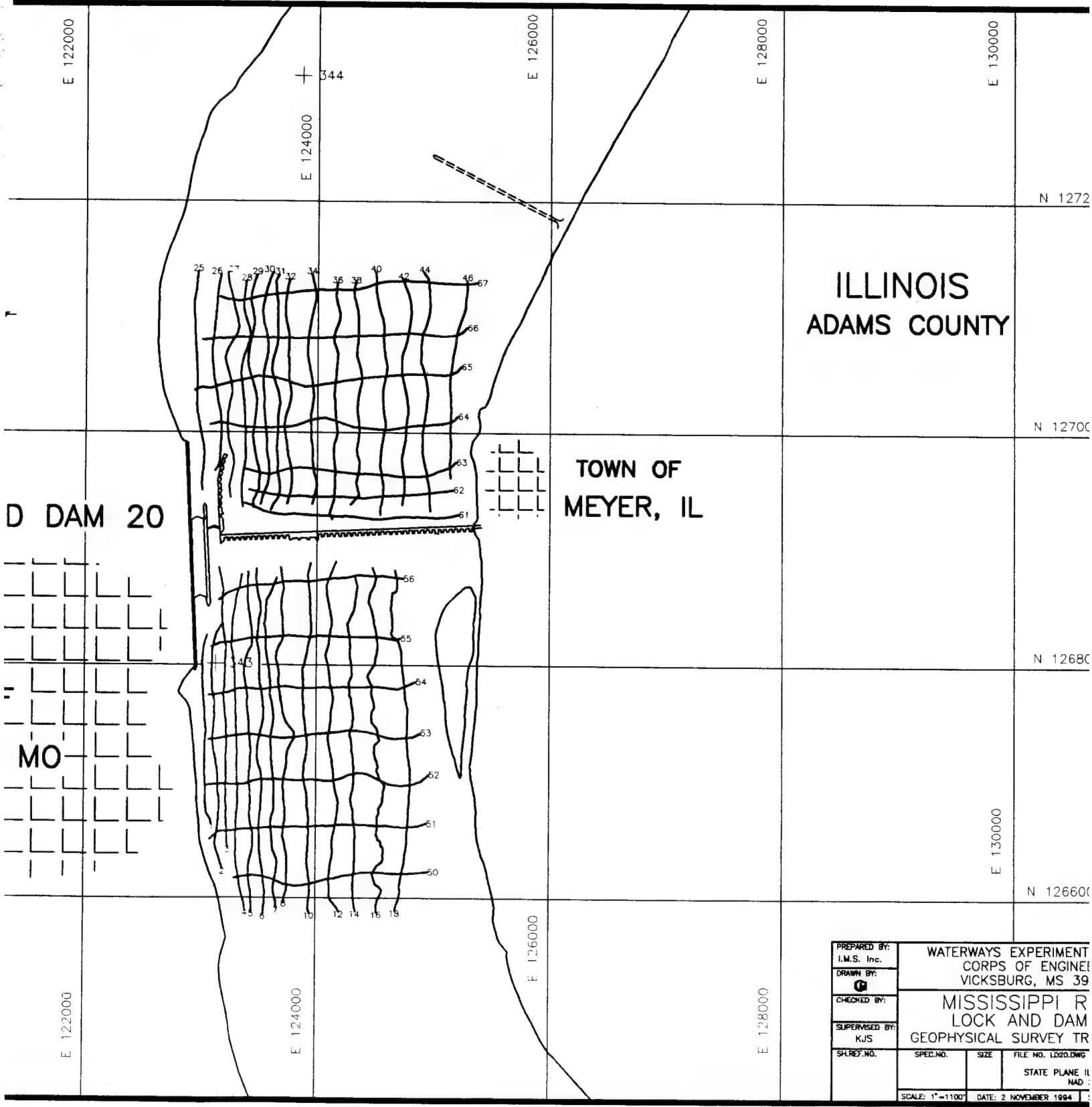
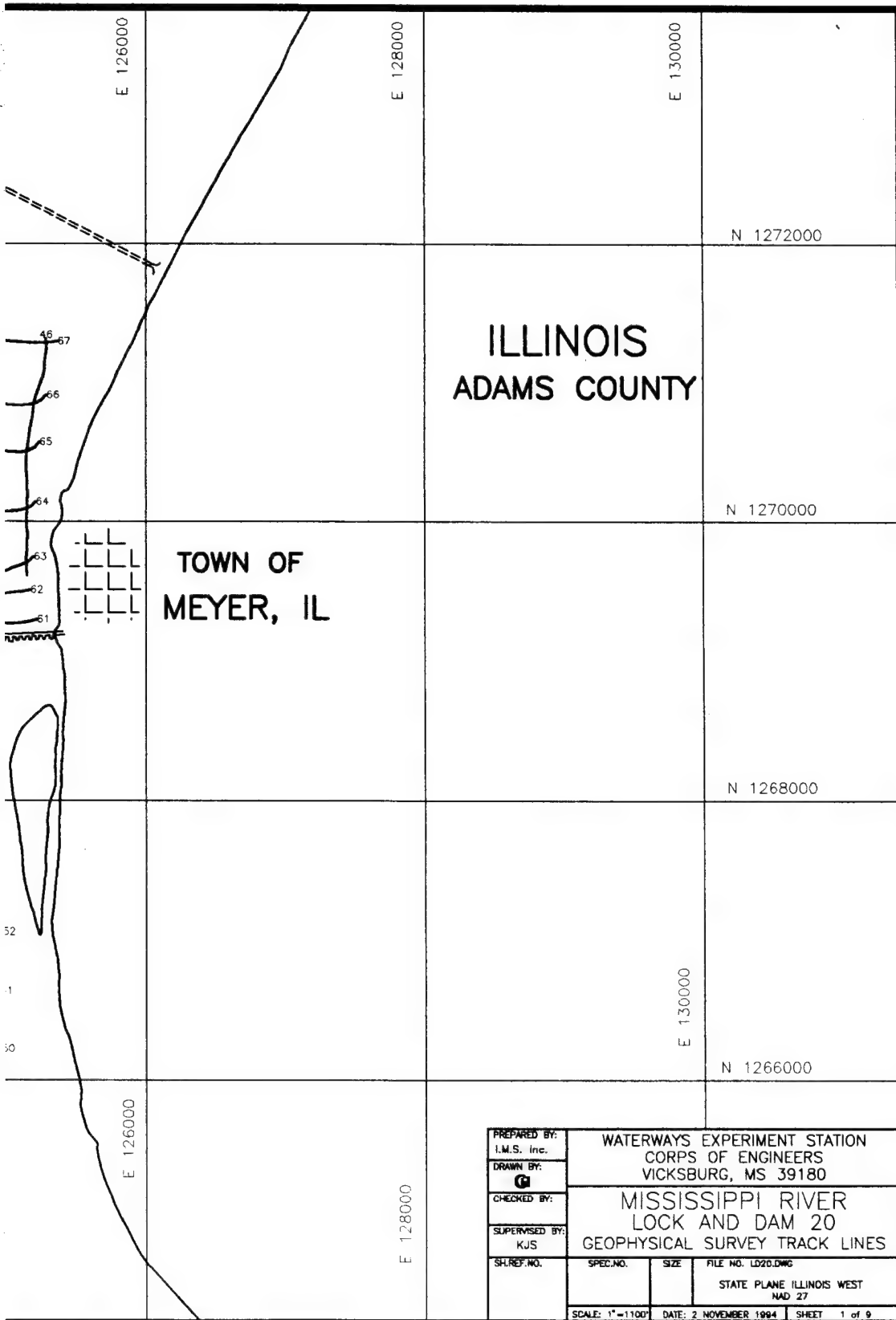


Figure 3. Seismic reflection survey lines, Lock and Dam 20



id Dam 20



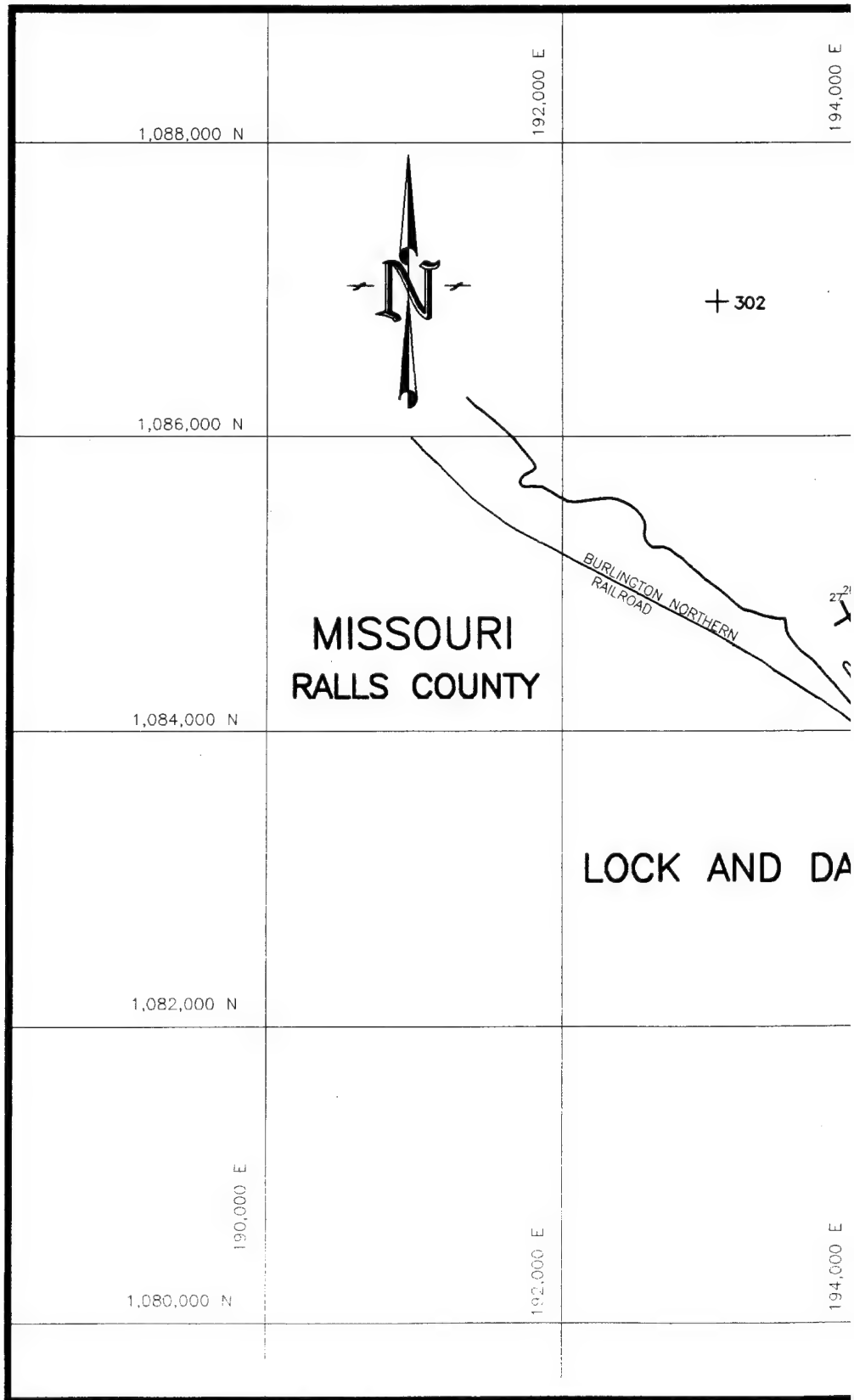
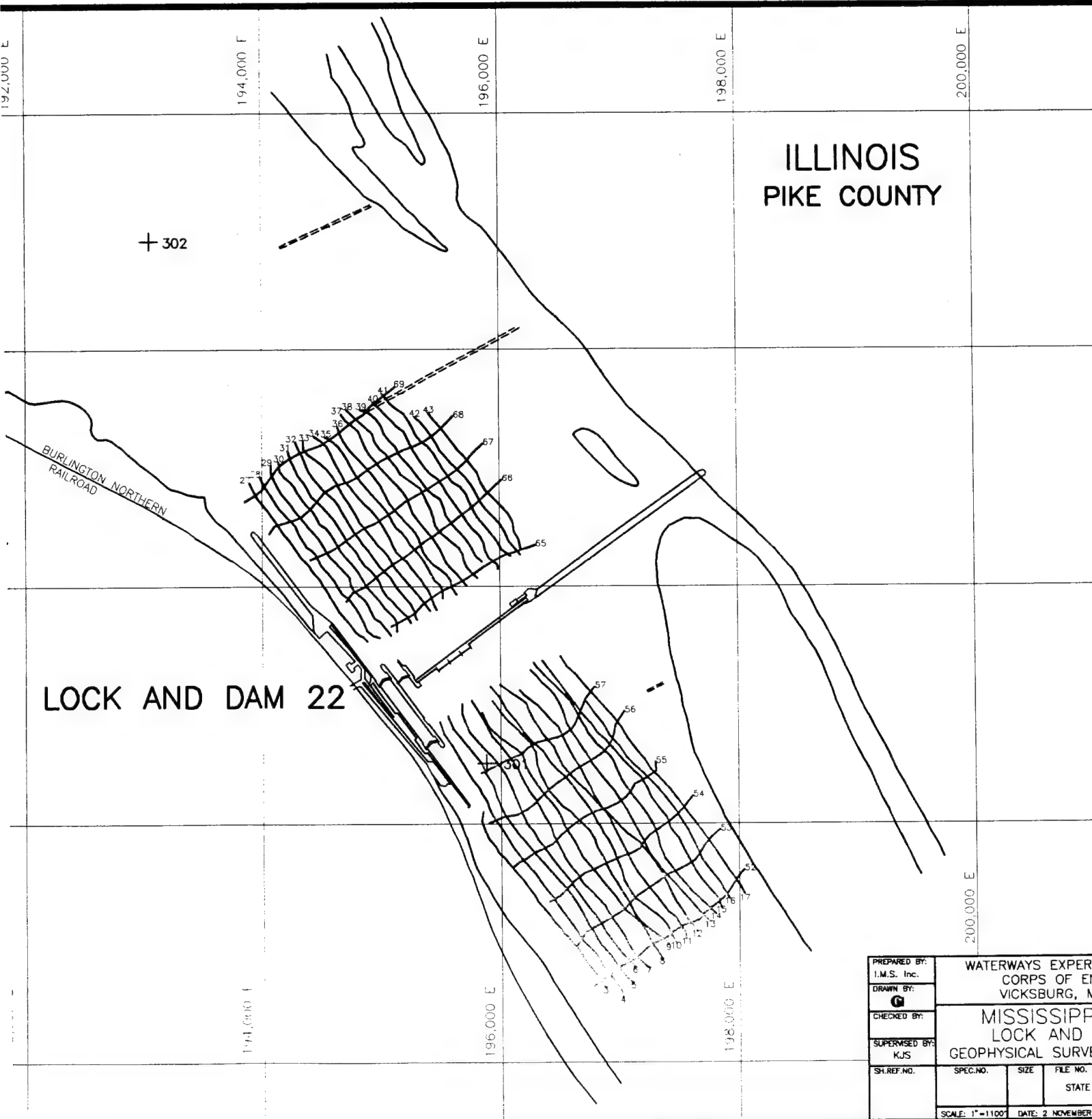


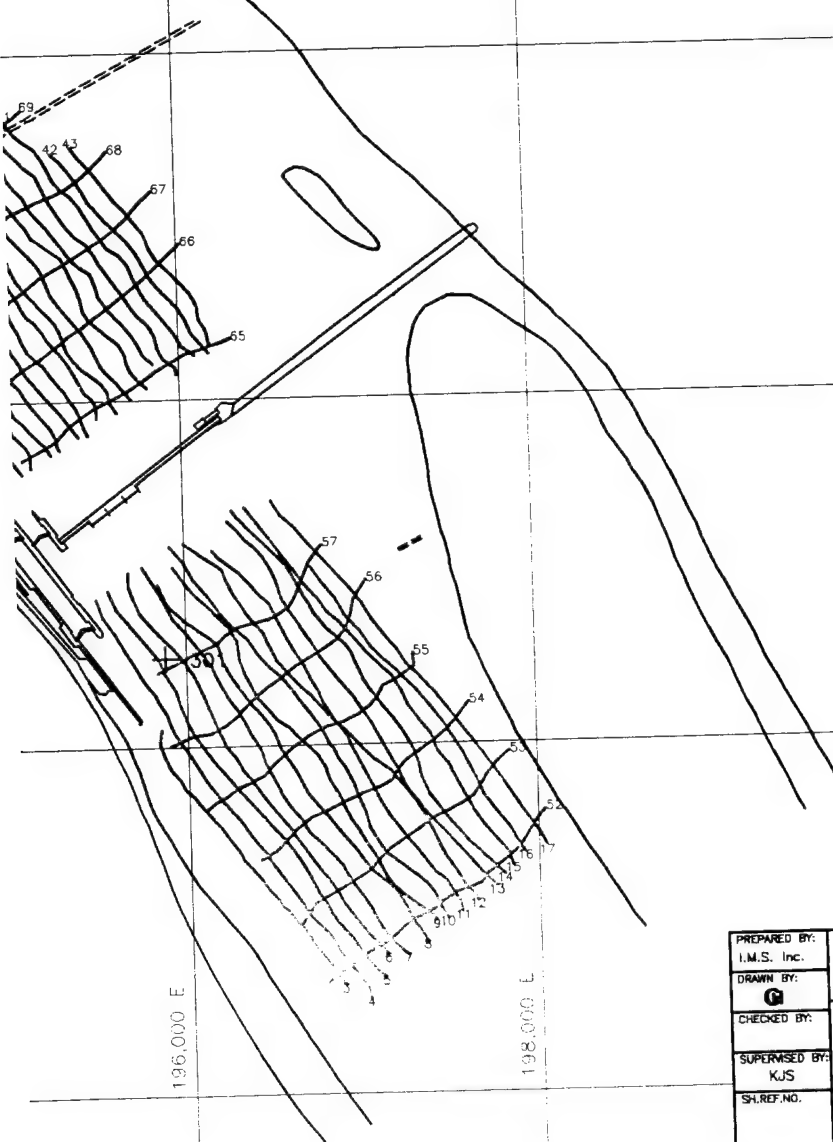
Figure 4. Seismic reflection survey lines, Lock and Dam 22




PREPARED BY: I.M.S. Inc.	WATERWAYS EXPERIMENTAL CORPS OF ENGINEERS VICKSBURG, MS		
DRAWN BY: G	MISSISSIPPI LOCK AND DAM GEOPHYSICAL SURVEY		
CHECKED BY:	STATE P		
SUPERVISED BY: KJS	SPEC. NO.	SIZE	FILE NO. LD
SURF. NO.			
SCALE: 1"=1100'		DATE: 2 NOVEMBER 1	

ind Dam 22

ILLINOIS PIKE COUNTY



PREPARED BY: I.M.S. Inc.	WATERWAYS EXPERIMENT STATION CORPS OF ENGINEERS VICKSBURG, MS 39180		
DRAWN BY: 	MISSISSIPPI RIVER LOCK AND DAM 22 GEOPHYSICAL SURVEY TRACK LINES		
CHECKED BY:			
SUPERVISED BY: KJS			
SHEET NO.	SPEC. NO.	SIZE	FILE NO. LD22.DWG
			STATE PLANE ILLINOIS WEST NAD 27
SCALE: 1"=1100'		DATE: 2 NOVEMBER 1994	SHEET 4 of 8

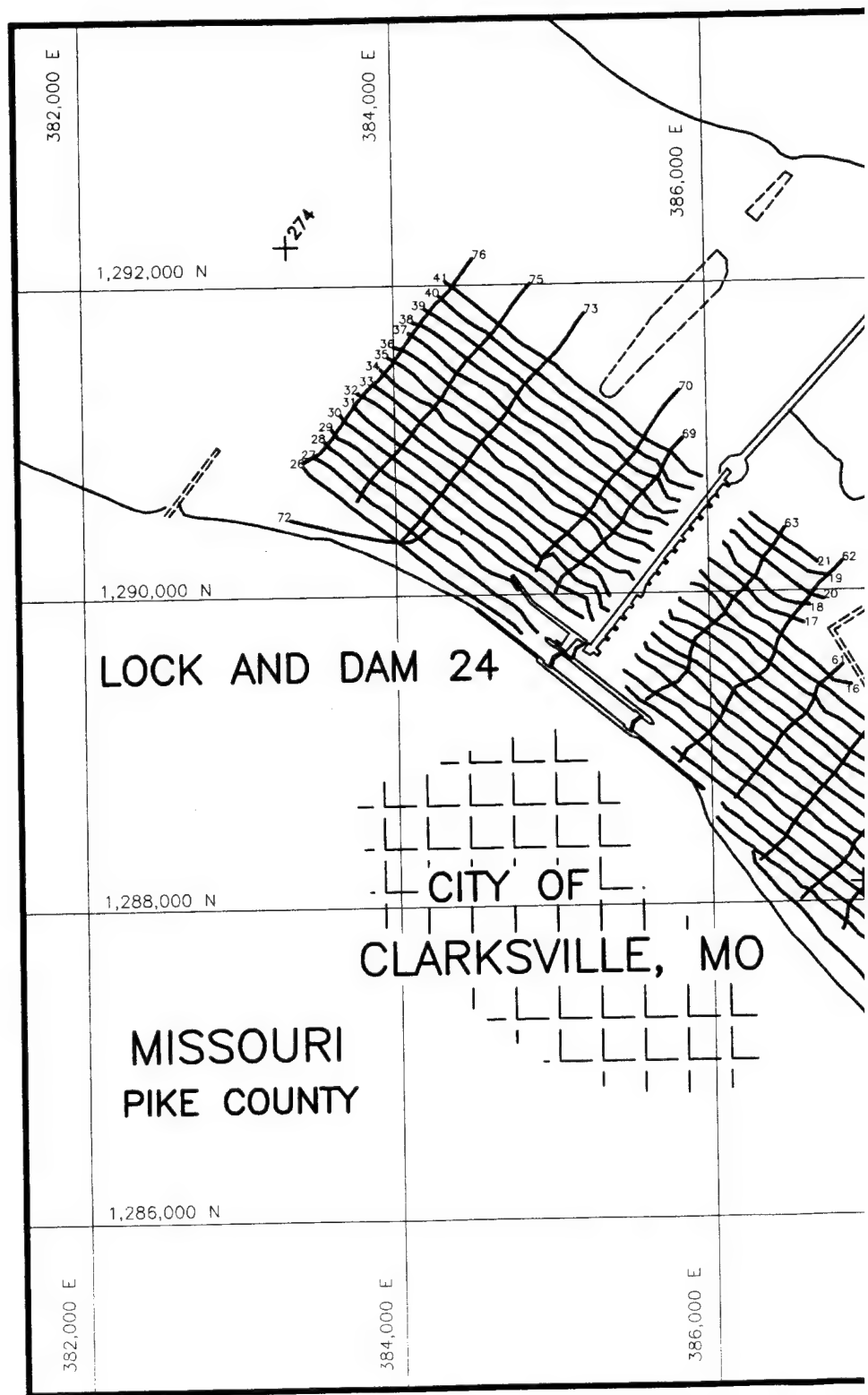
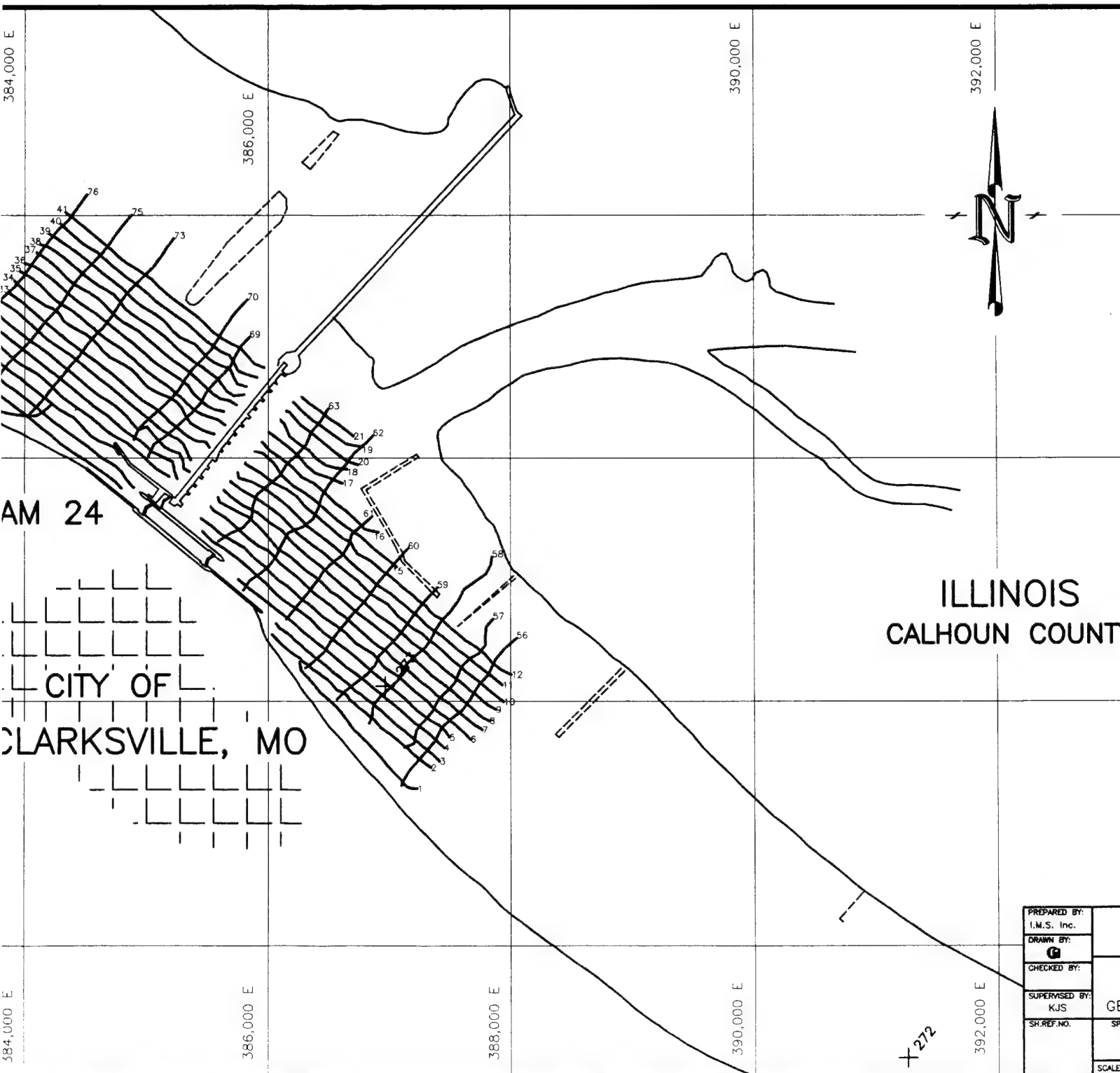
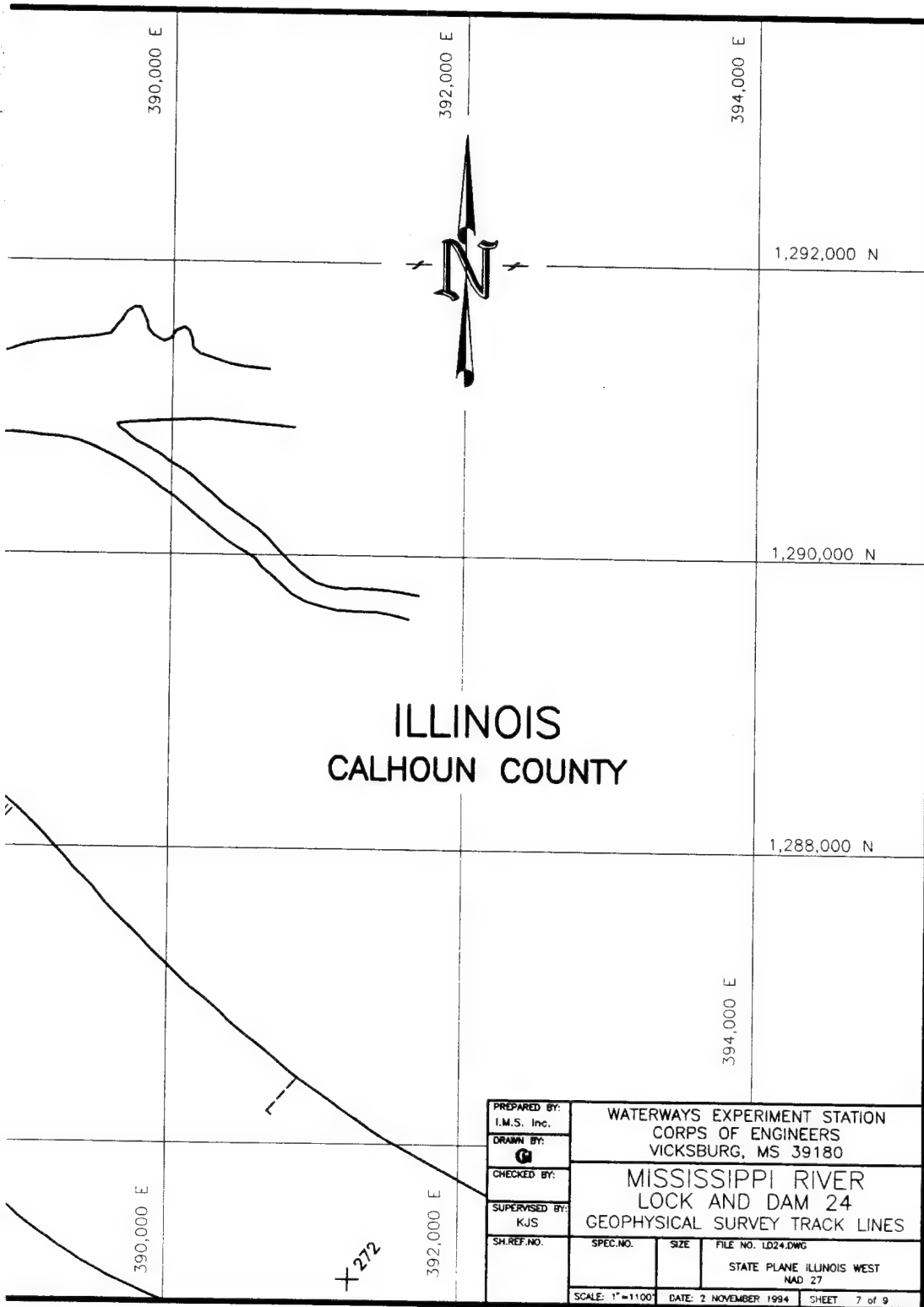


Figure 5. Seismic reflection survey lines, Lock and Dam 24



urvey lines, Lock and Dam 24



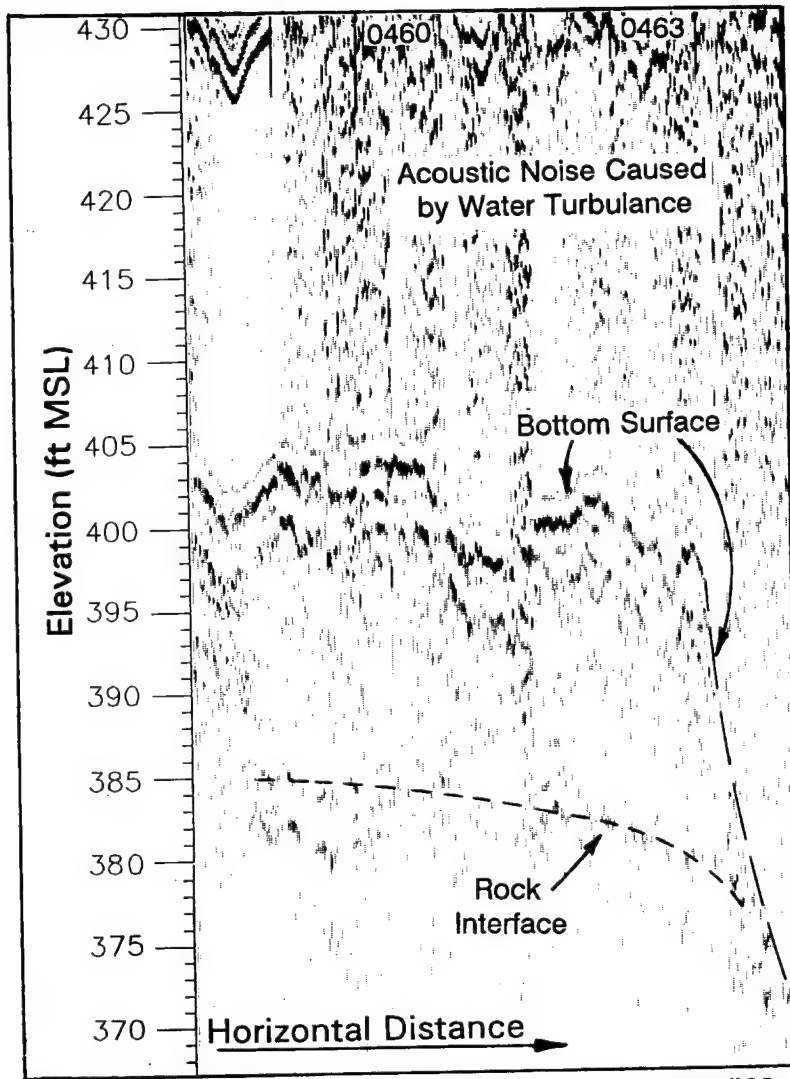


Figure 6. Acoustic noise along 'boomer' survey line #63 caused by water turbulence downstream of Lock and Dam 24

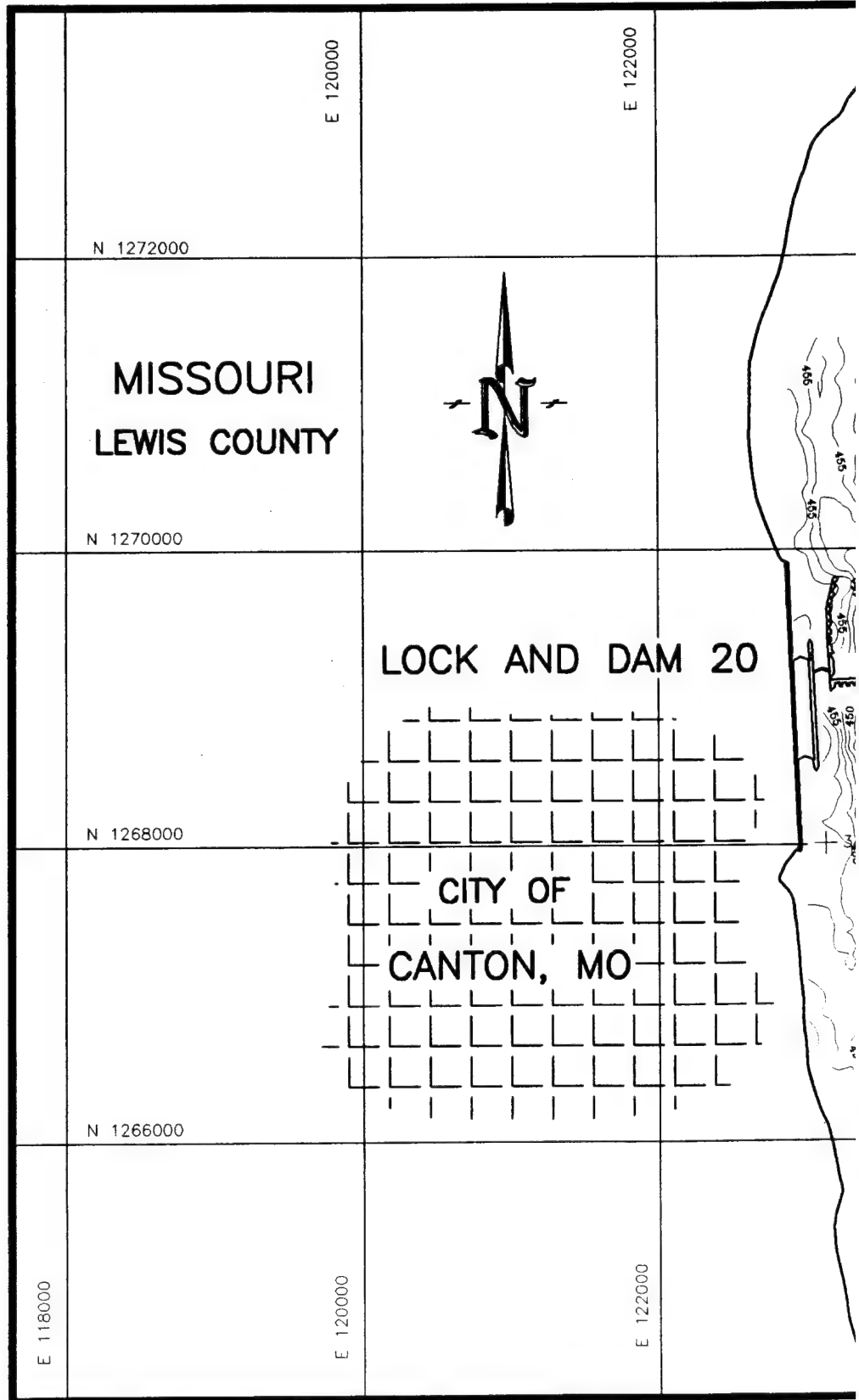


Figure 7. River bottom elevation plot, Lock and Dam 20

E 122000

E 124000

E 126000

E 128000

E 130000



ILLINOIS
ADAMS COUNTY

LOCK AND DAM 20

TOWN OF
MEYER, IL

CITY OF
ST. LOUIS, MO

NOTE:
CONTOUR INTERVAL
@ 2.5 FT

E 122000

E 124000

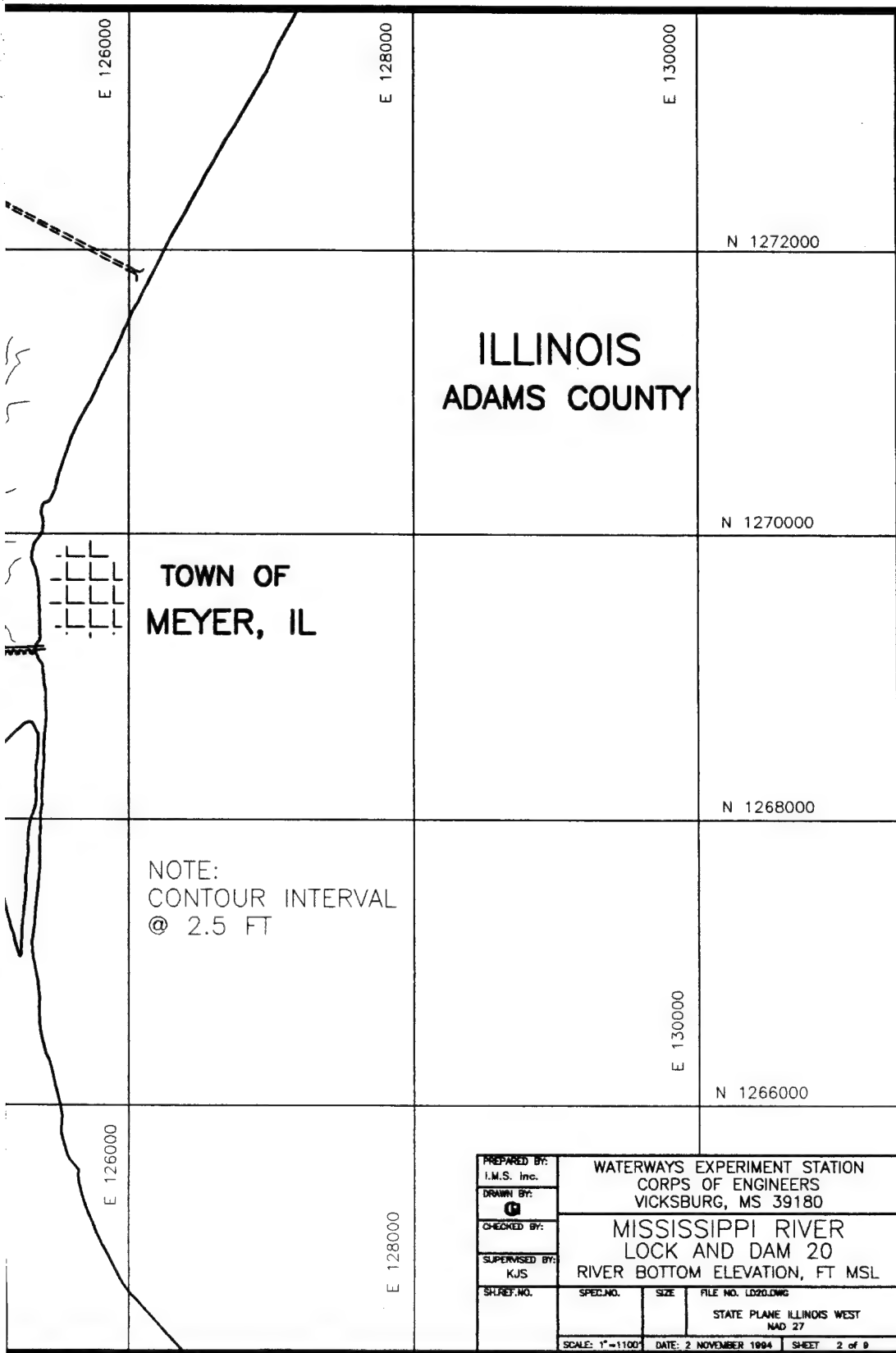
E 126000

E 128000

E 130000

PREPARED BY: I.M.S. Inc.	WATERWAYS CORP VICKS	
DRAWN BY: C	MISSISSIPPI LOCK RIVER BOTTOM	
CHECKED BY:		
SUPERVISED BY: KJS		
SH. REF. NO.	SPEC. NO.	SIZE
SCALE: 1"=1100'		
DATE:		

Lock and Dam 20



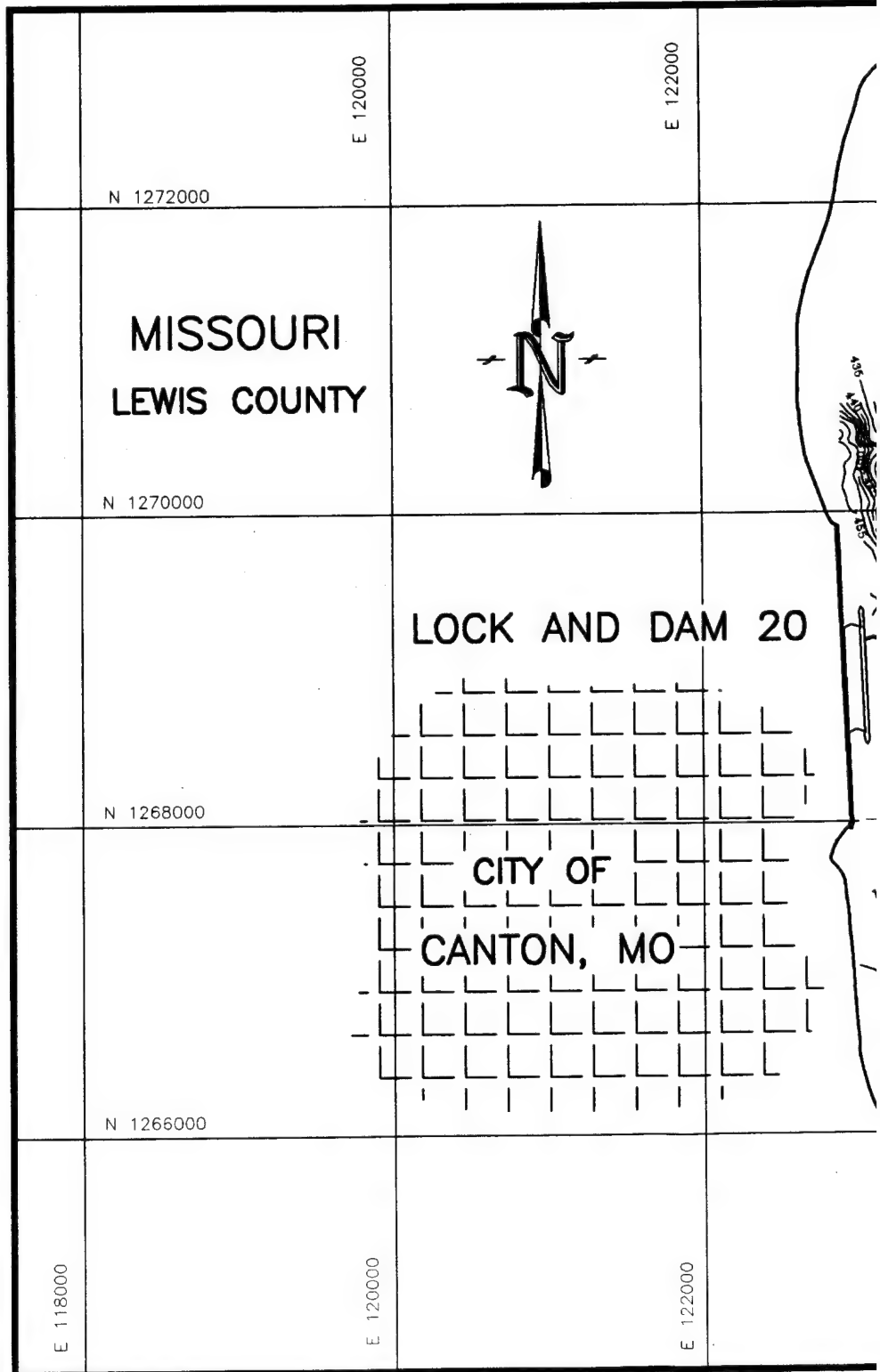
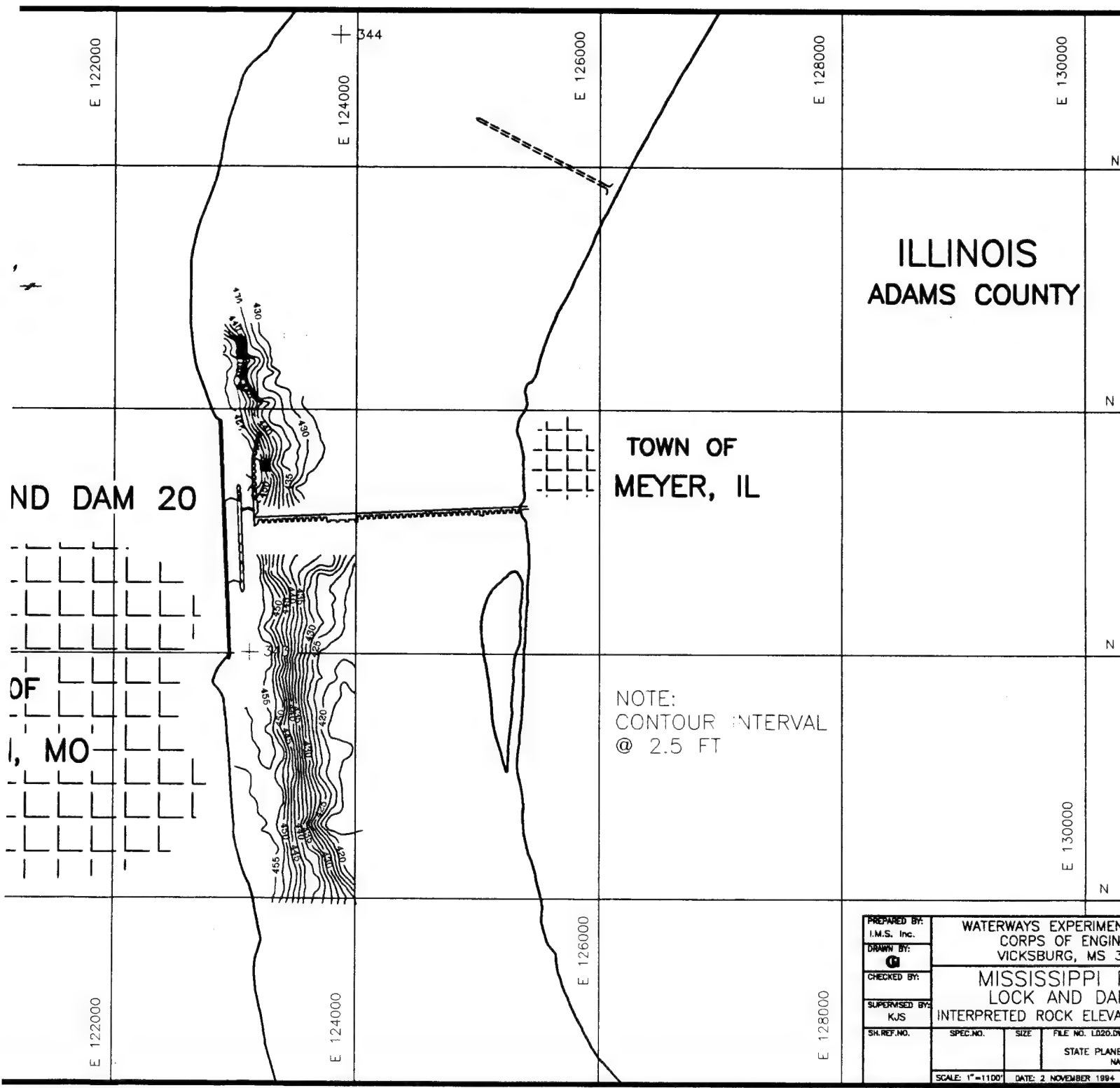
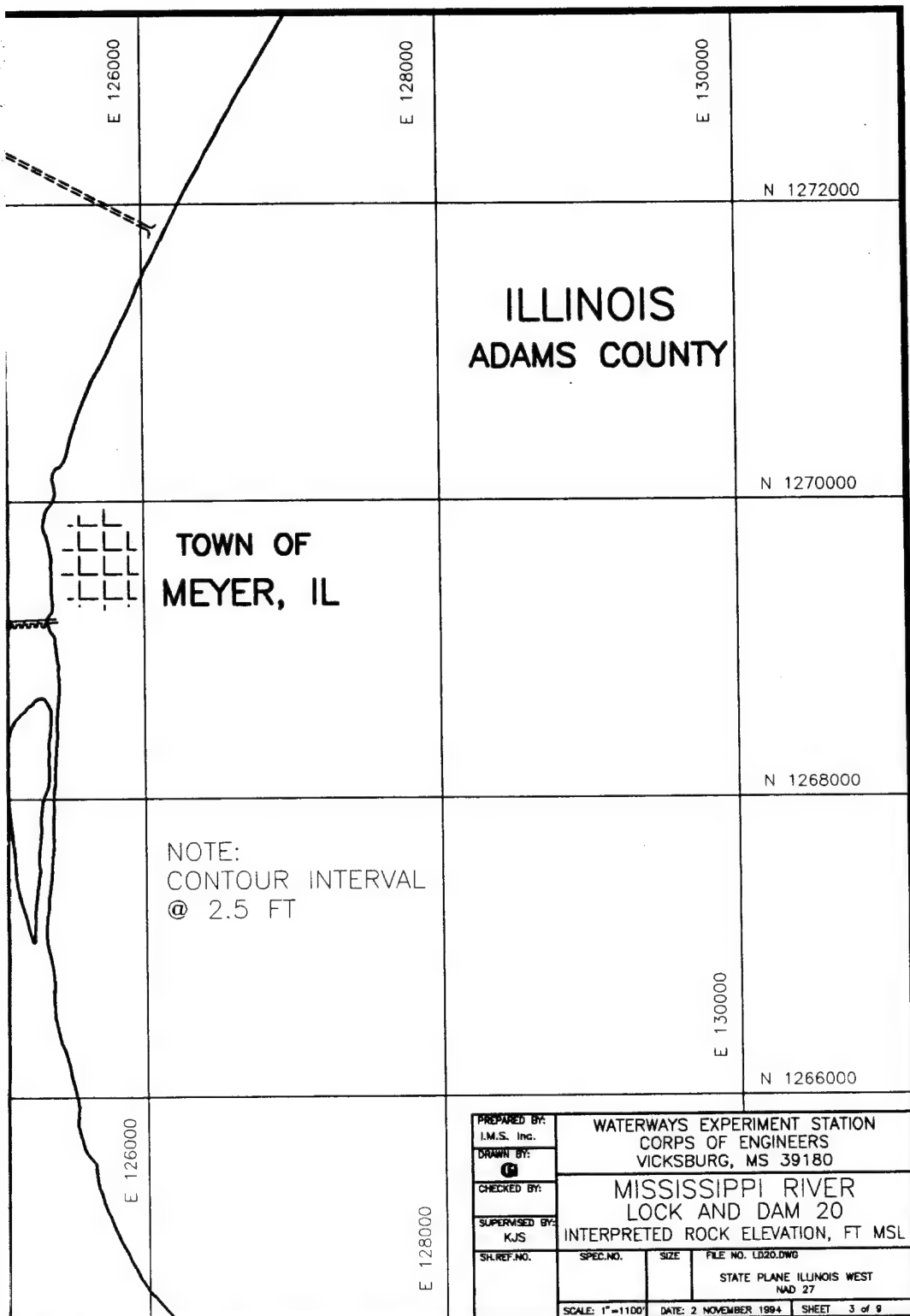


Figure 8. Interpreted rock surface elevation map, Lock and Dam 20. Rep



Lock and Dam 20. Representative CENCR core locations are also illustrated



ocations are also illustrated

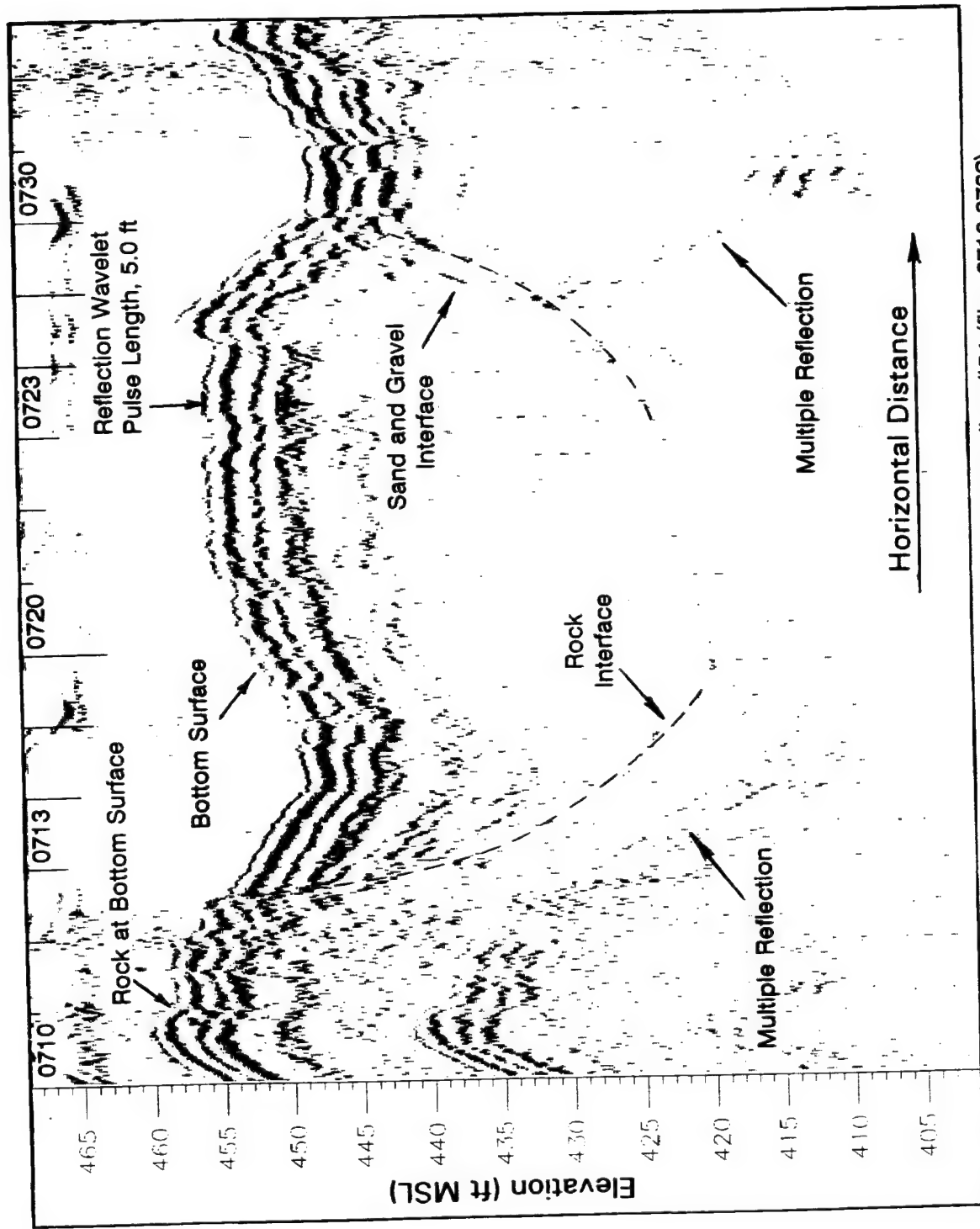


Figure 9. Subbottom seismic reflection record along 'boomer' survey line #54 (files 0710-0732), downstream of Lock and Dam 20

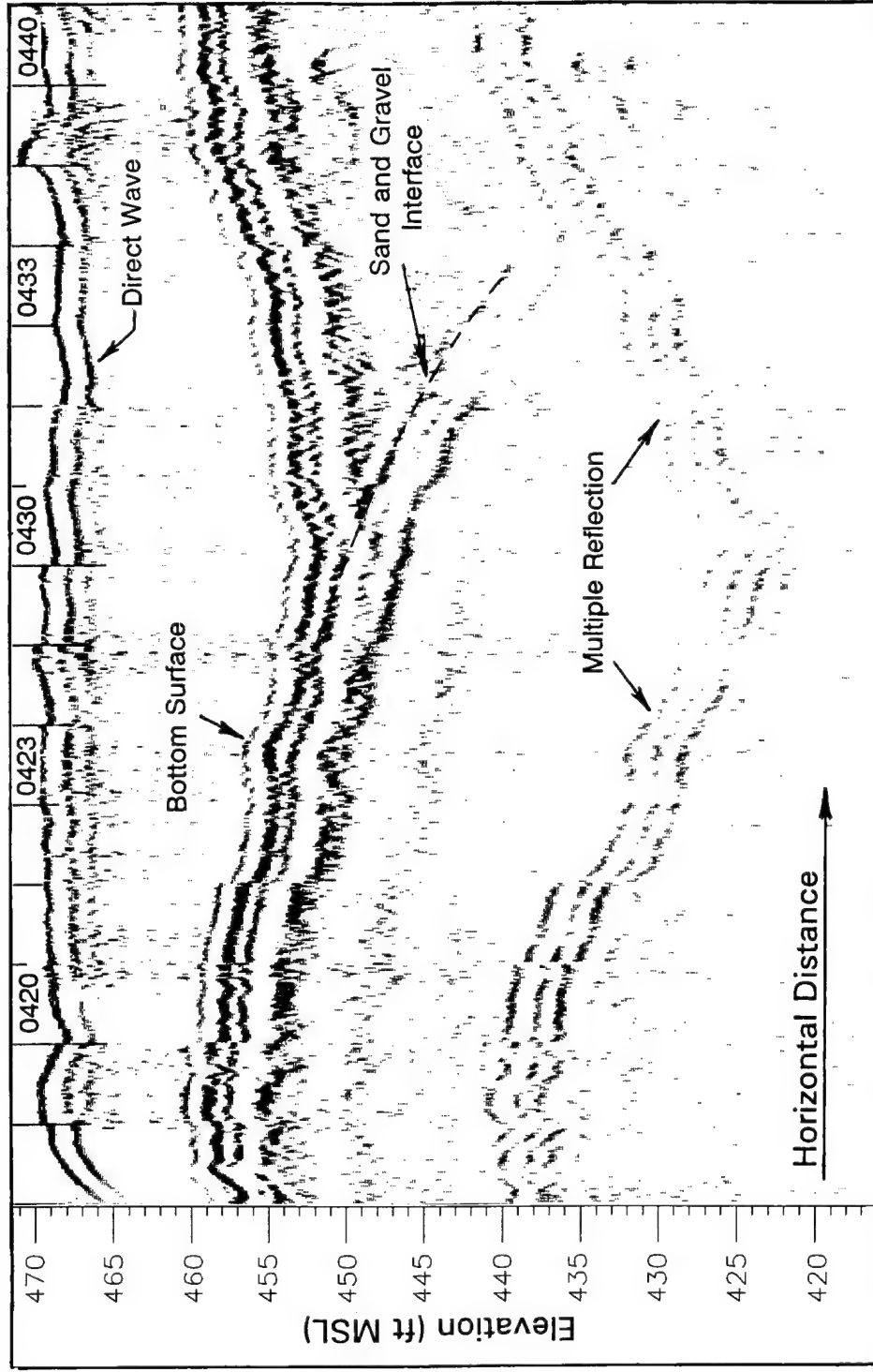


Figure 10. Subbottom seismic reflection record along 'boomer' survey line #44 (files 0414-0440), upstream of Lock and Dam 20

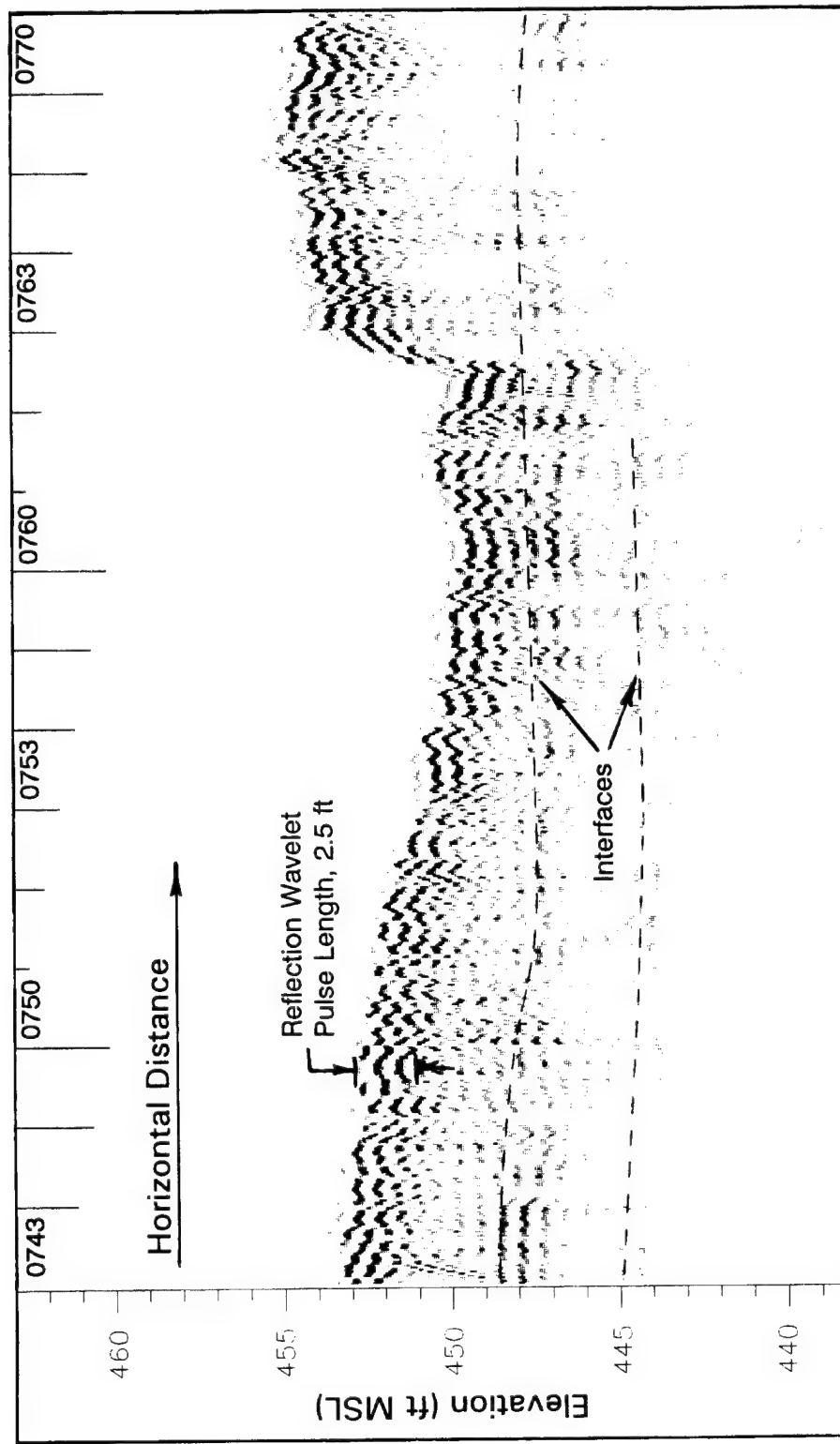


Figure 11. Subbottom seismic reflection record along 'pinger' survey line #12 (files 0743-0770), downstream of Lock and Dam 20

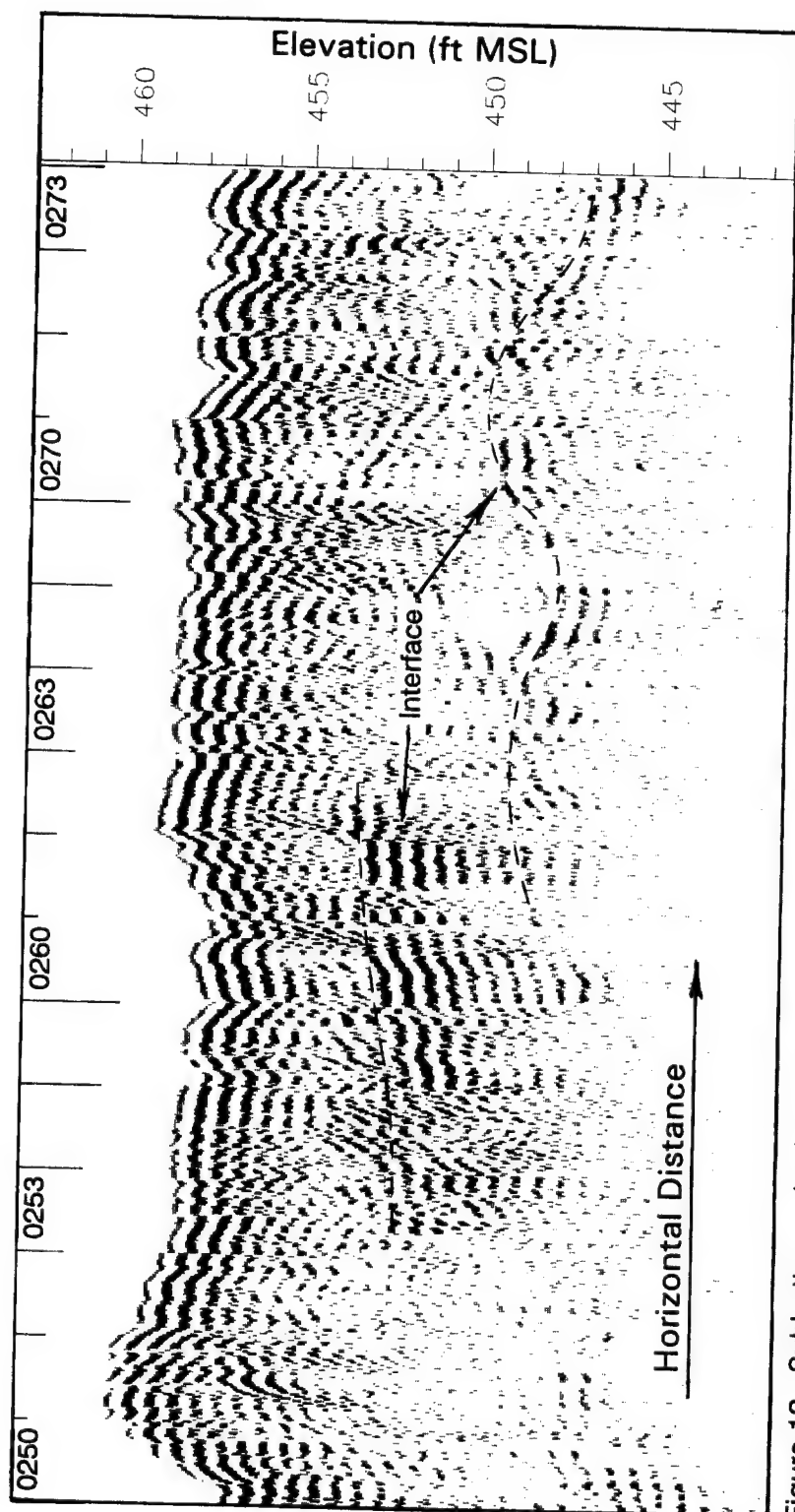


Figure 12. Subbottom seismic reflection record along 'pinger' survey line #29 (files 0250-0273), upstream of Lock and Dam 20

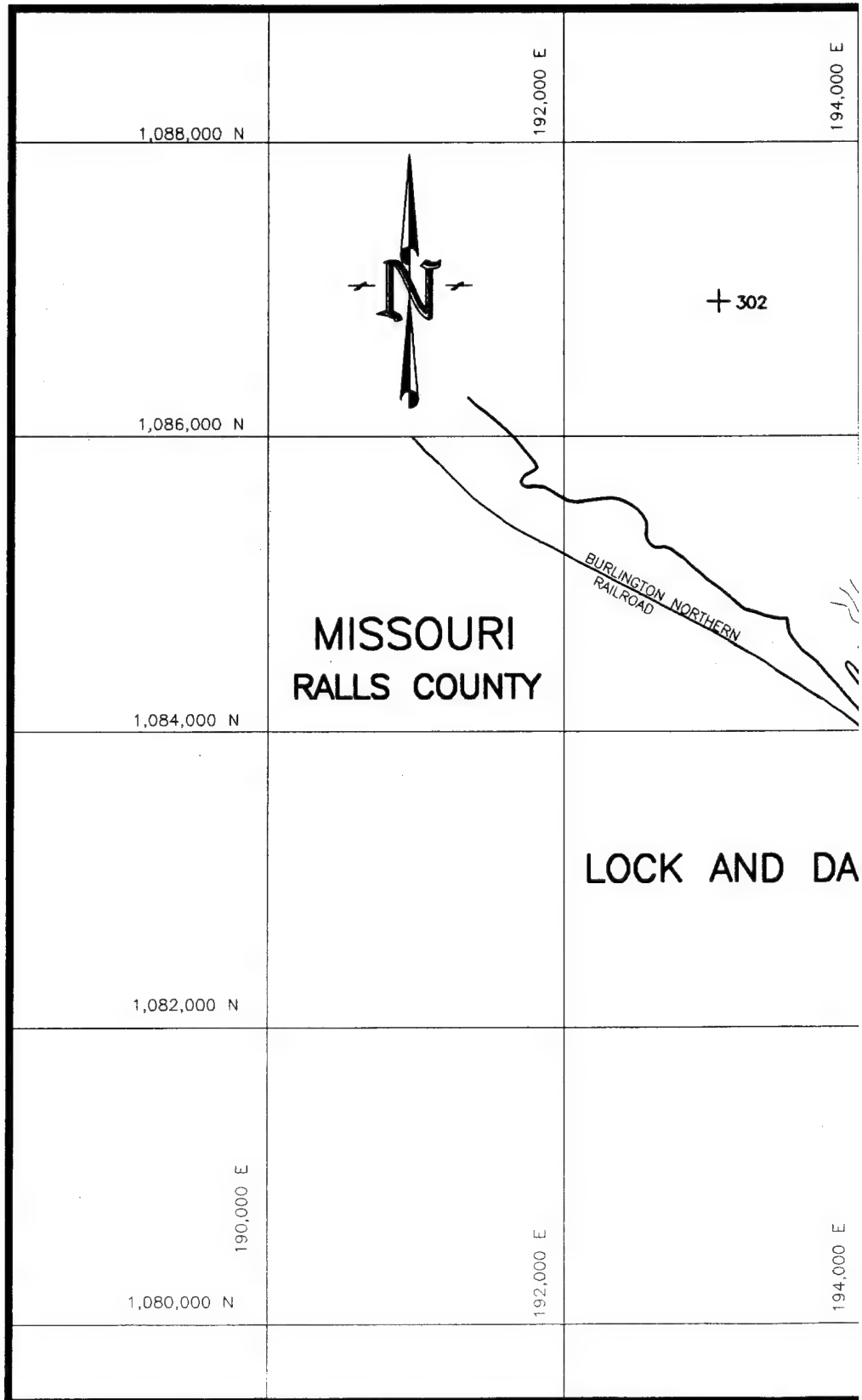
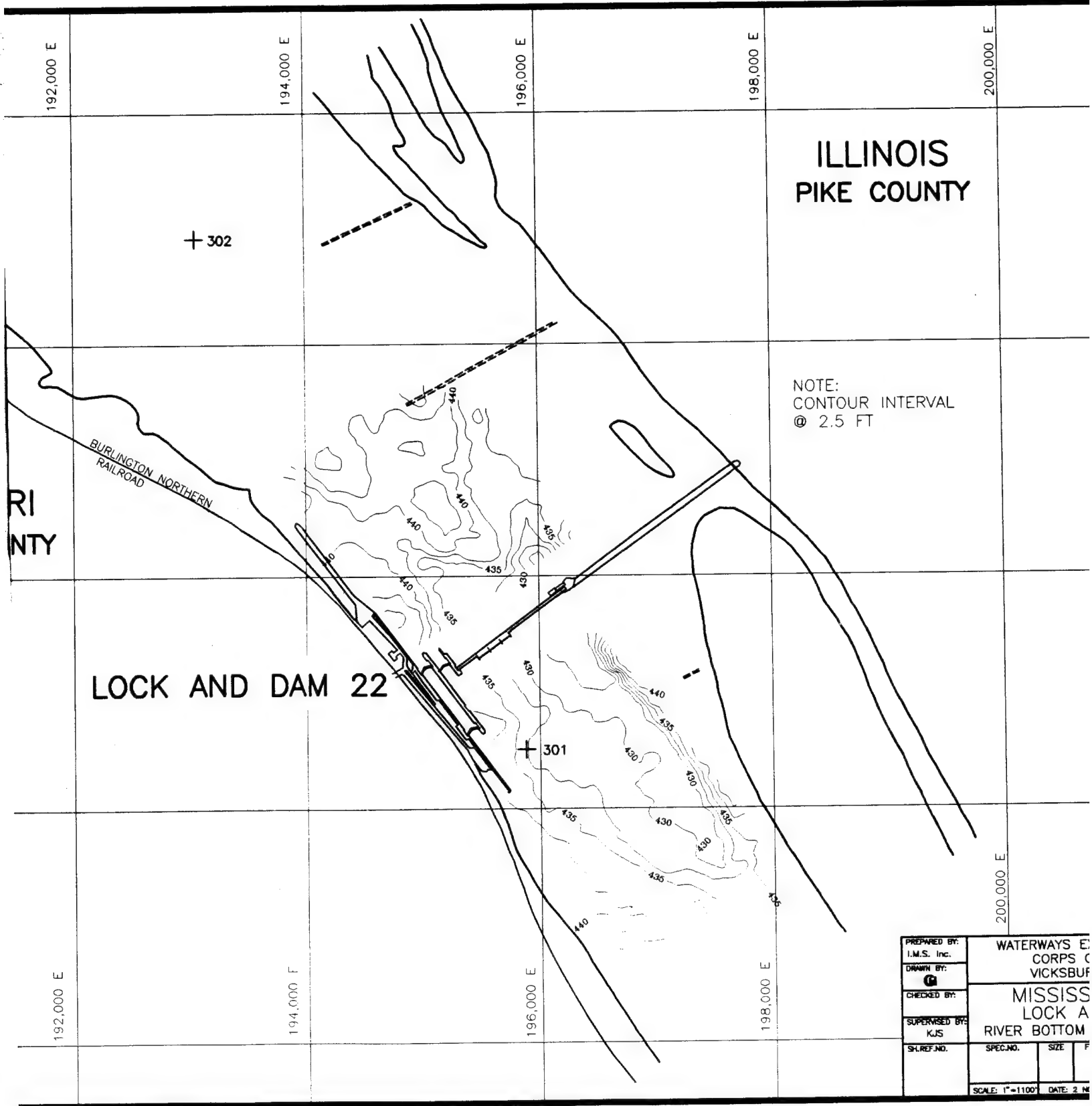
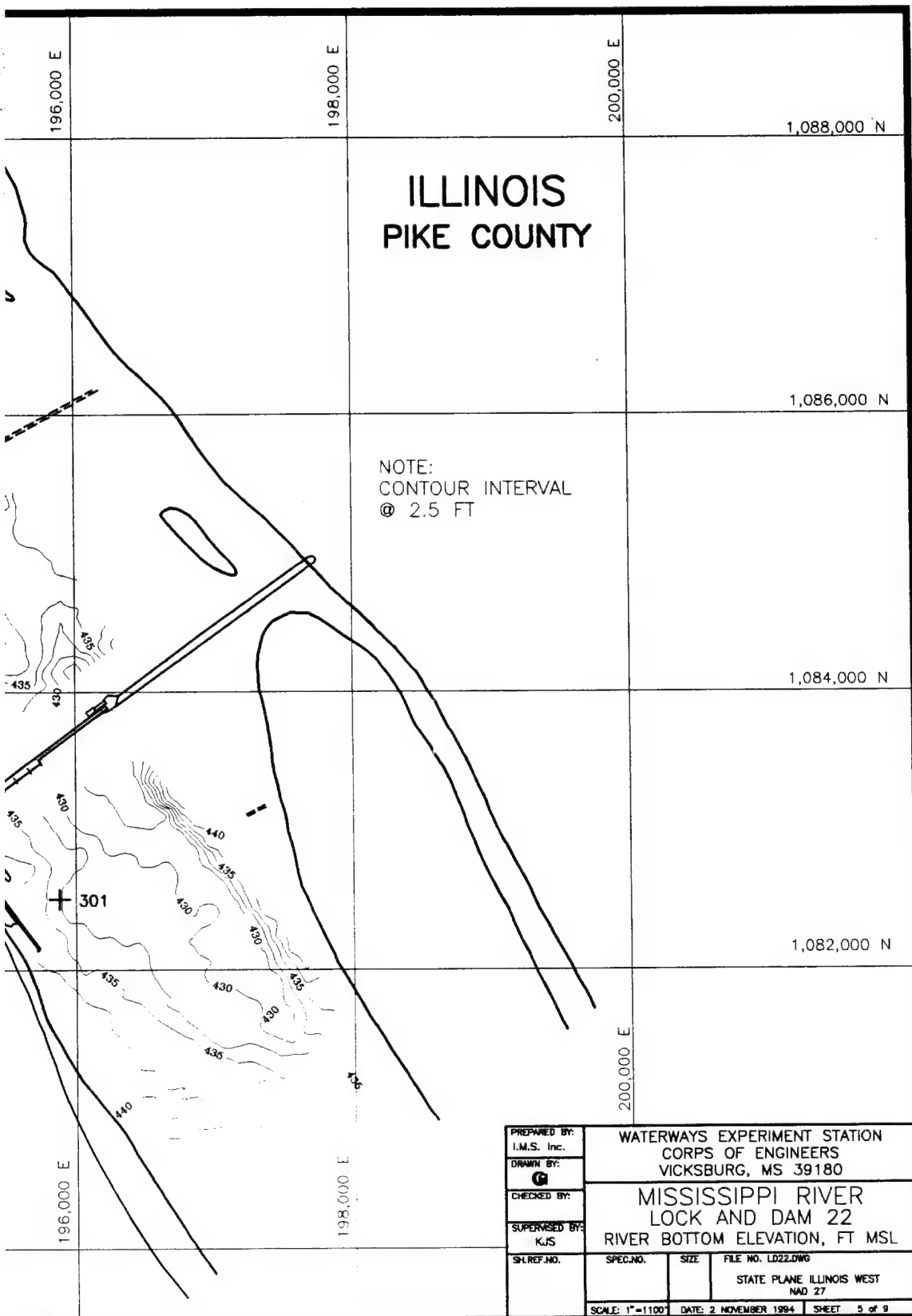


Figure 13. River bottom elevation plot, Lock and Dam 22



Lock and Dam 22



PREPARED BY: I.M.S. Inc.	WATERWAYS EXPERIMENT STATION CORPS OF ENGINEERS VICKSBURG, MS 39180		
DRAWN BY: 			
CHECKED BY:	MISSISSIPPI RIVER LOCK AND DAM 22		
SUPERVISED BY: KJS	RIVER BOTTOM ELEVATION, FT MSL		
SH. REF. NO.	SPEC. NO.	SIZE	FILE NO. LD22.DWG
			STATE PLANE ILLINOIS WEST NAD 27
SCALE: 1"=1100'		DATE: 2 NOVEMBER 1994	SHEET 5 of 9

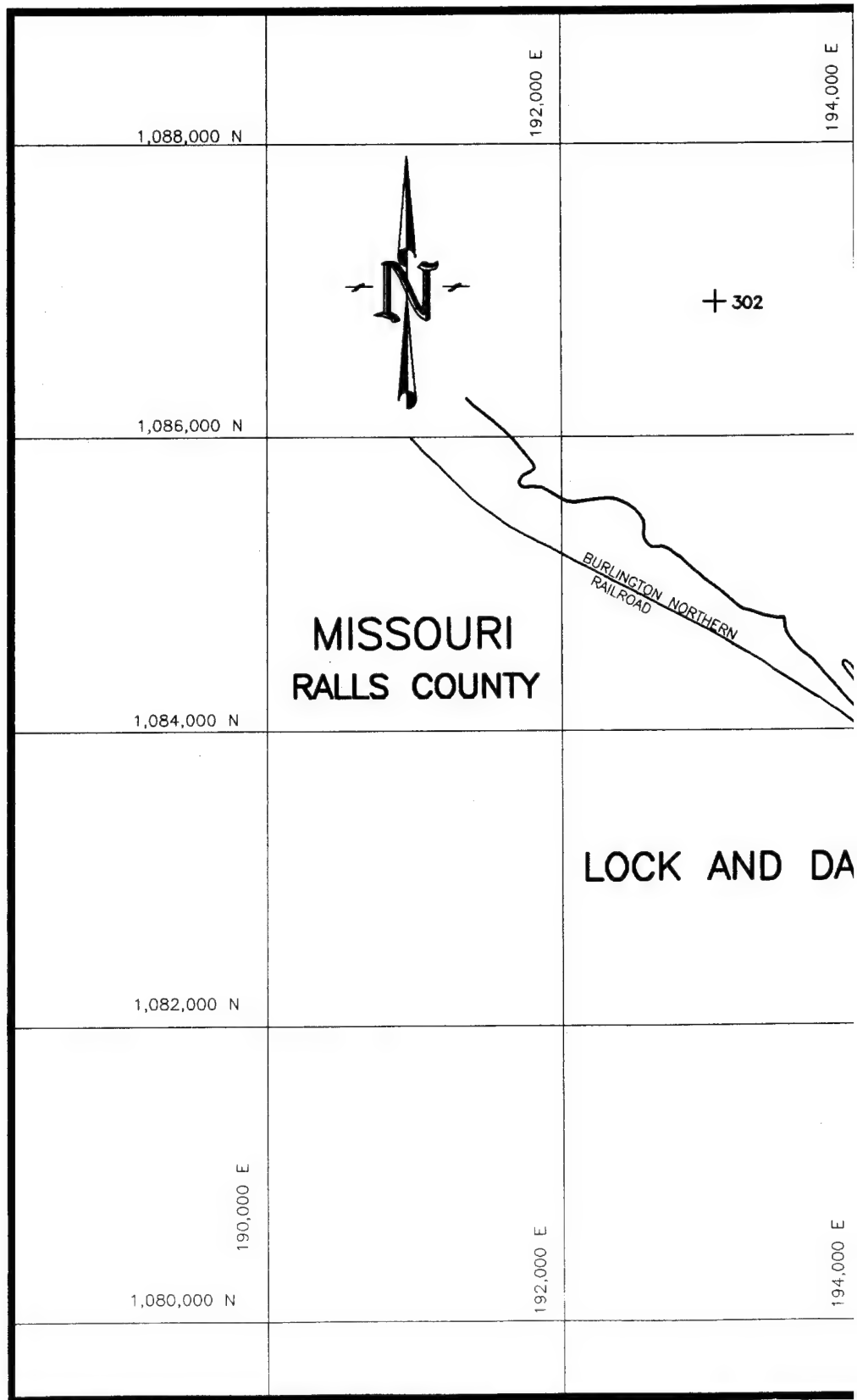
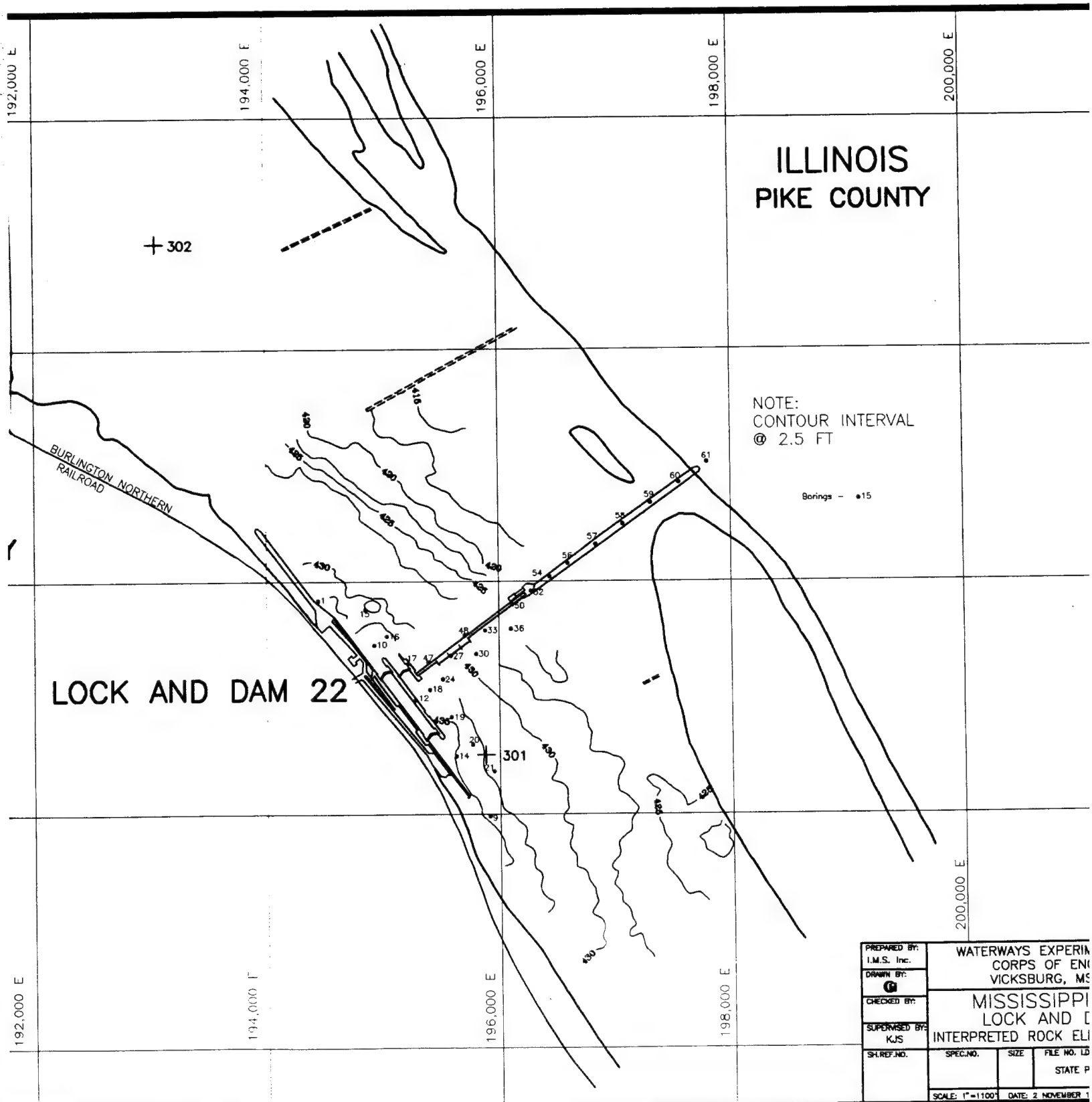


Figure 14. Interpreted rock surface elevation map, Lock and Dam 22. Repre



map, Lock and Dam 22. Representative CENCR core locations are also illustrated

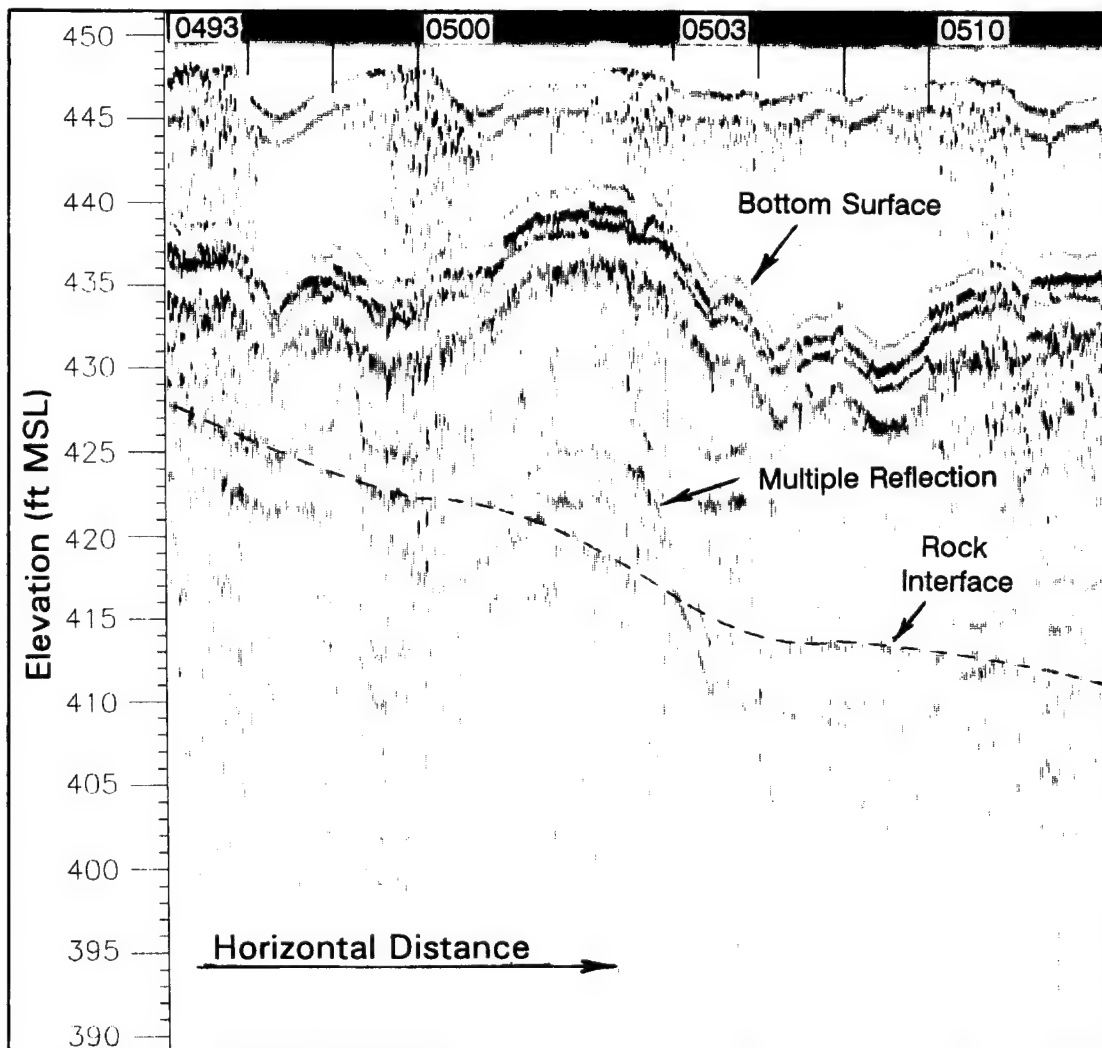


Figure 15. Subbottom seismic reflection record along 'boomer' survey line #67 (files 0493-0511), upstream of Lock and Dam 22

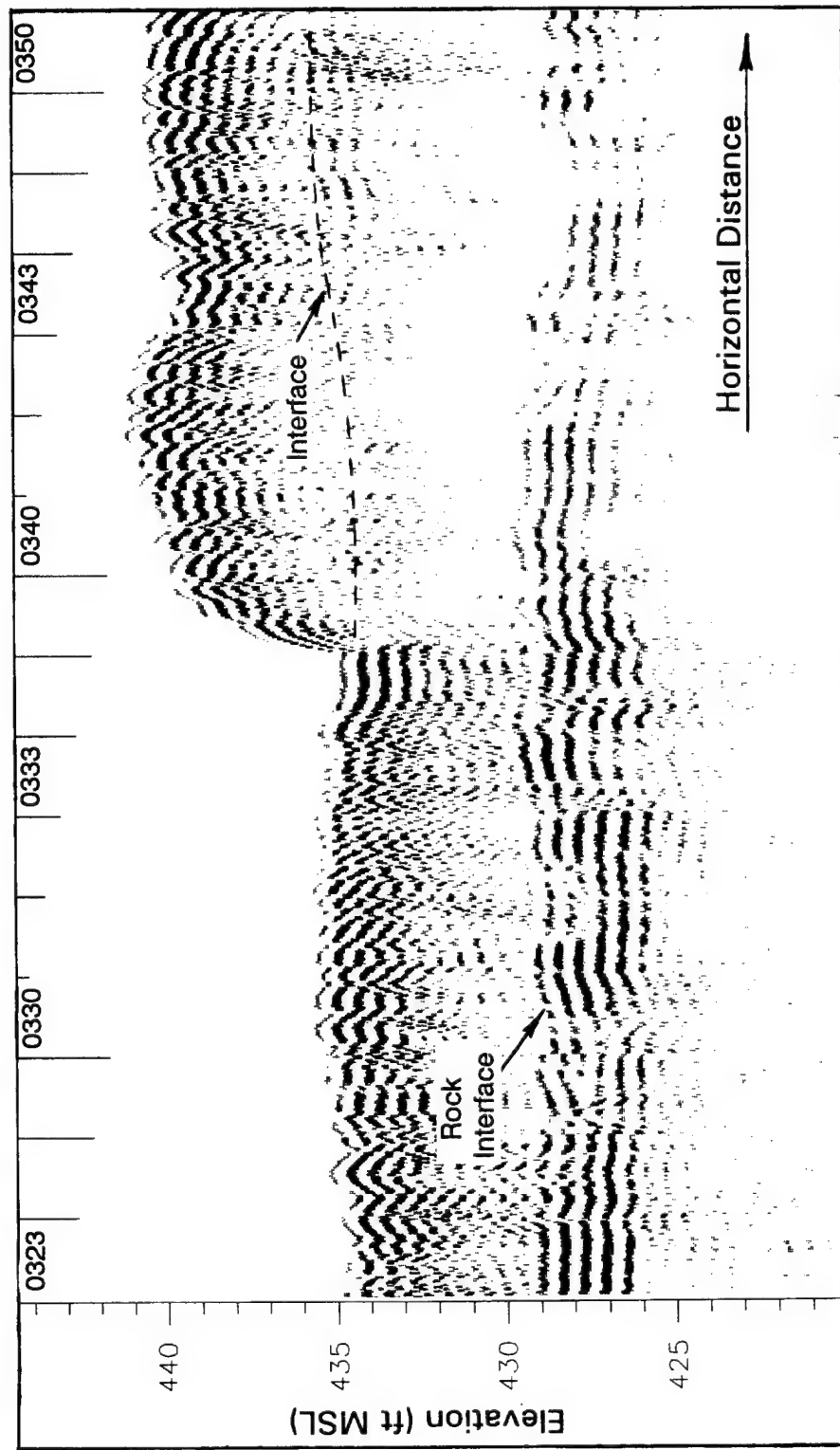


Figure 16. Subbottom seismic reflection record along 'pinger' survey line #33 (files 0323-0350), upstream of Lock and Dam 22

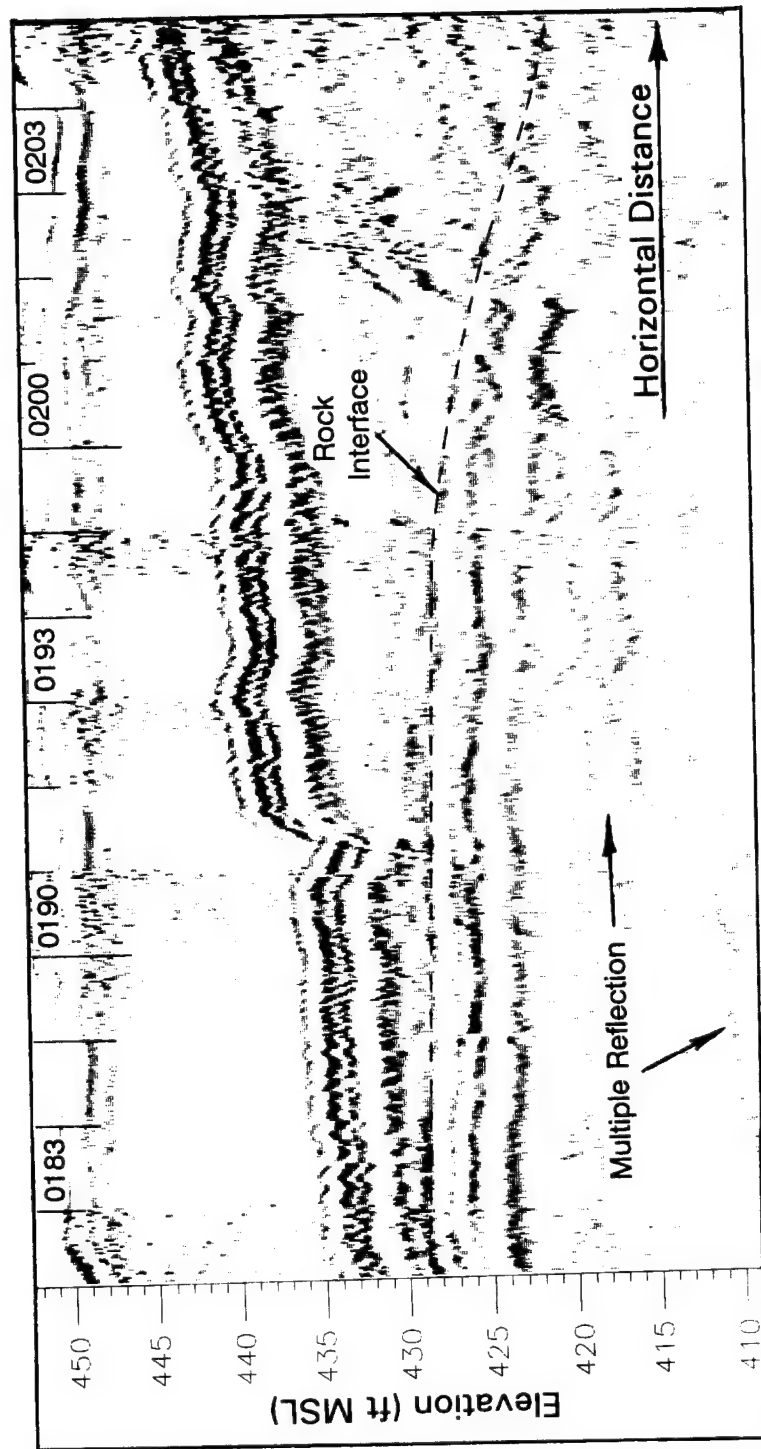


Figure 17. Subbottom seismic reflection record along 'boomer' survey line #33 (files 0182-0204), upstream of Lock and Dam 22

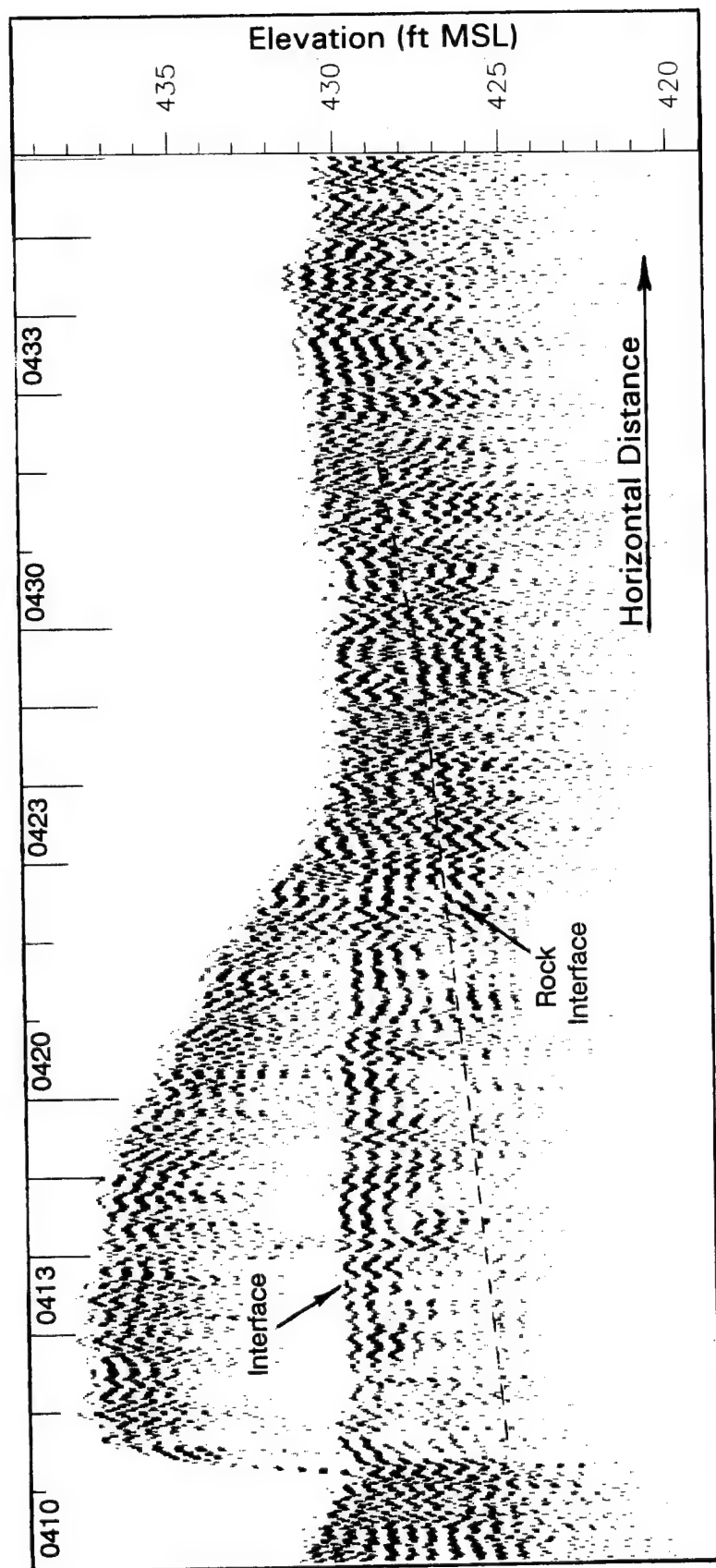


Figure 18. Subbottom seismic reflection record along 'pinger' survey line #10 (files 0410-0435), downstream of Lock and Dam 22

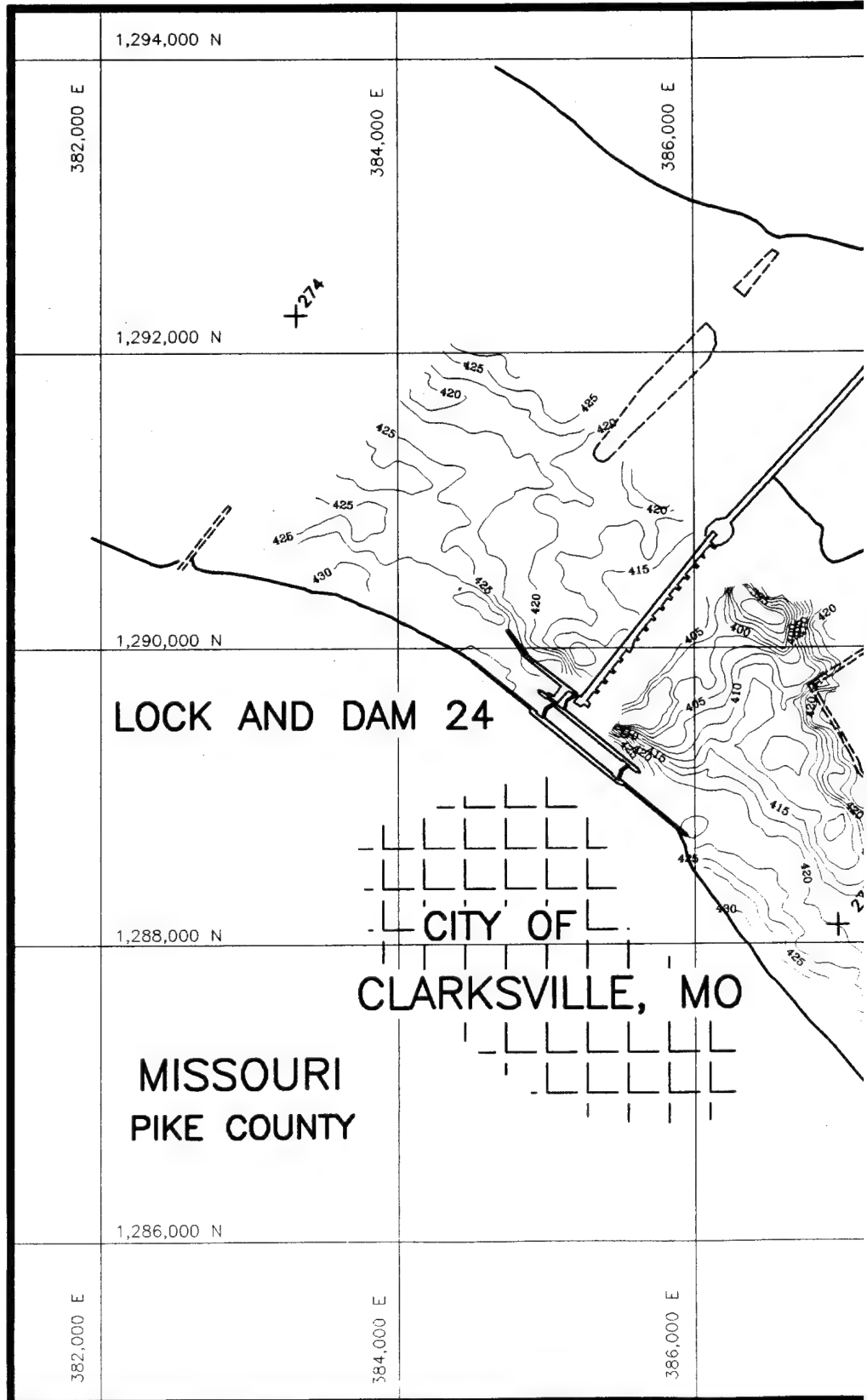
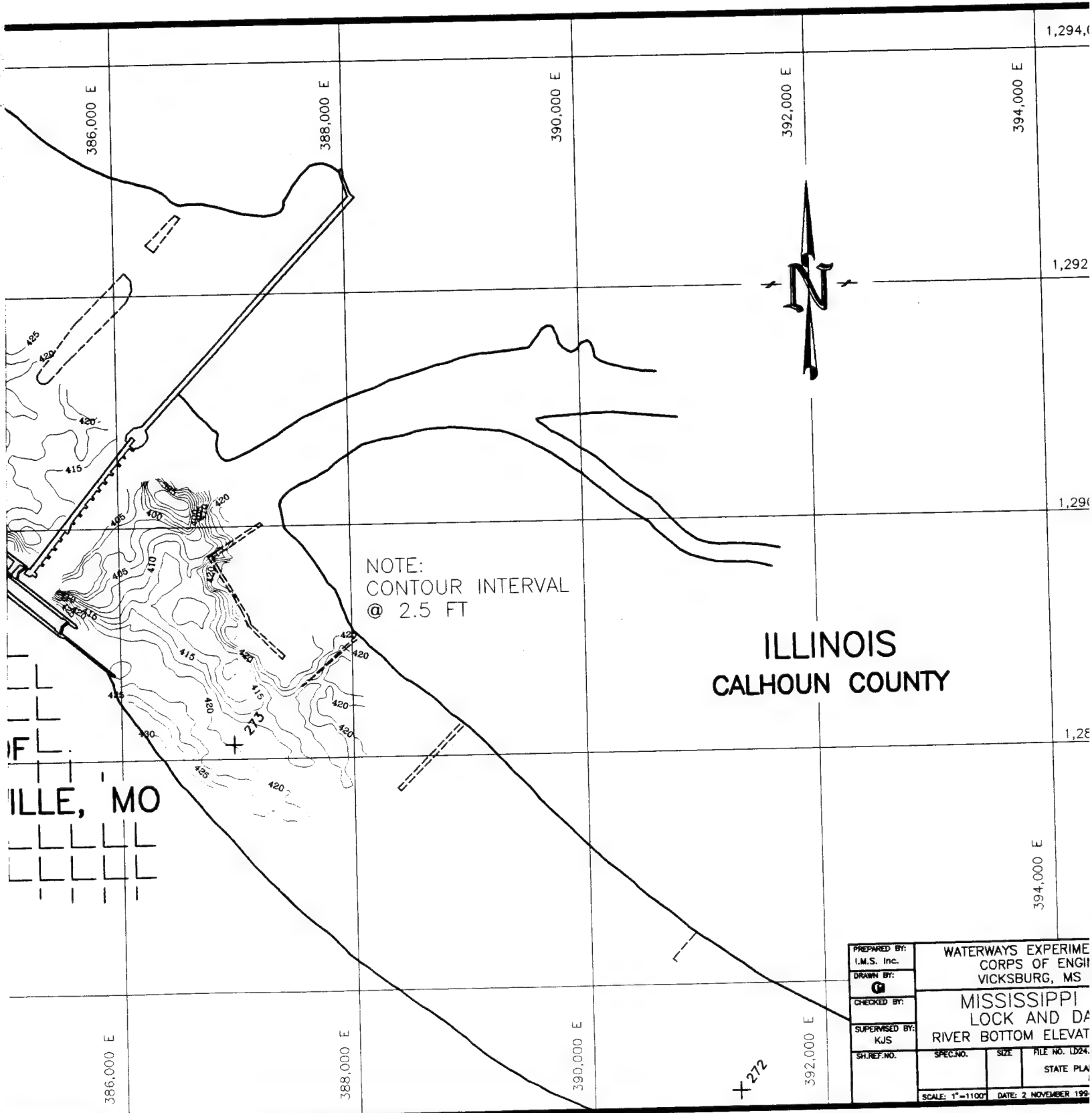
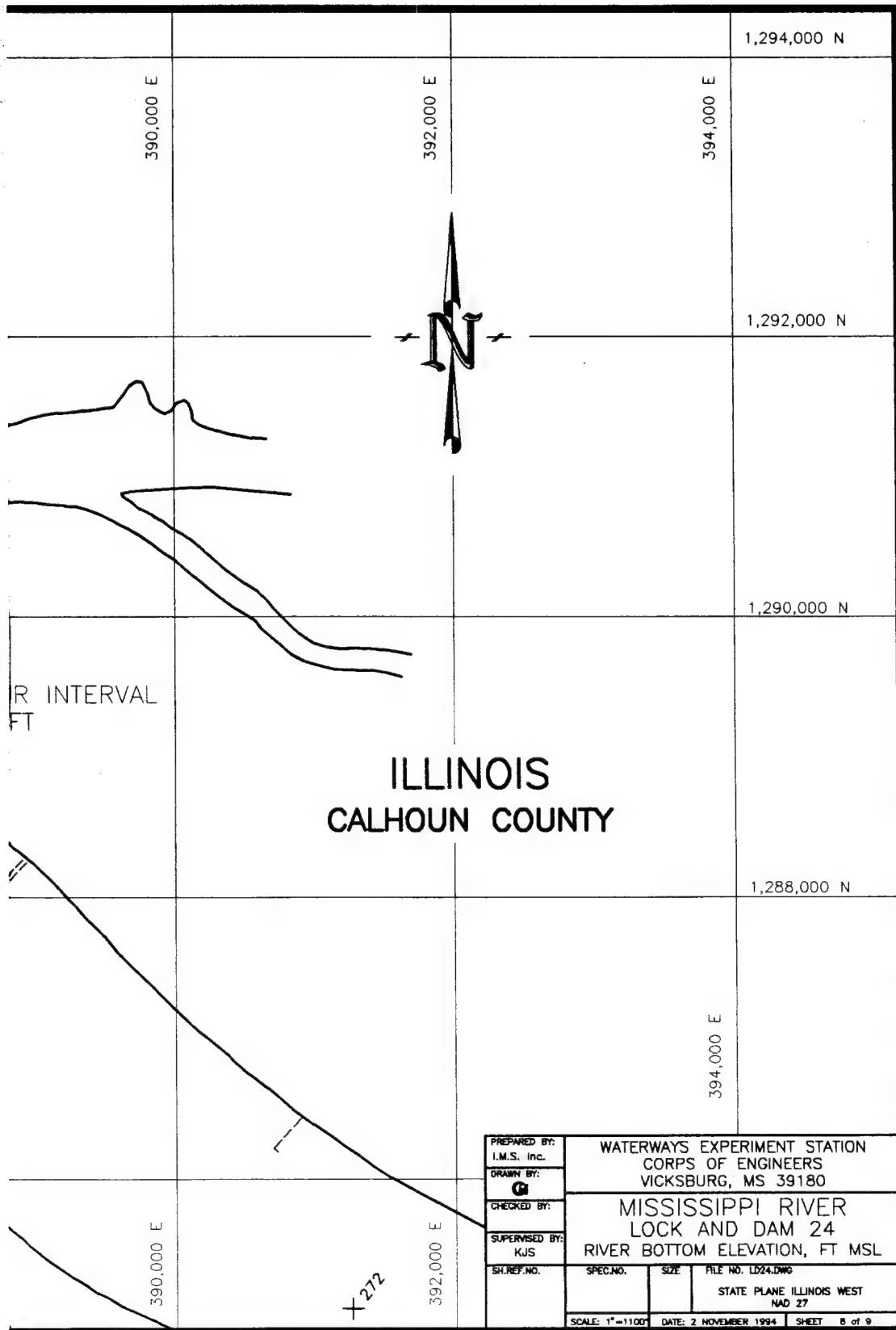


Figure 19. River bottom elevation plot, Lock and Dam 24



d Dam 24



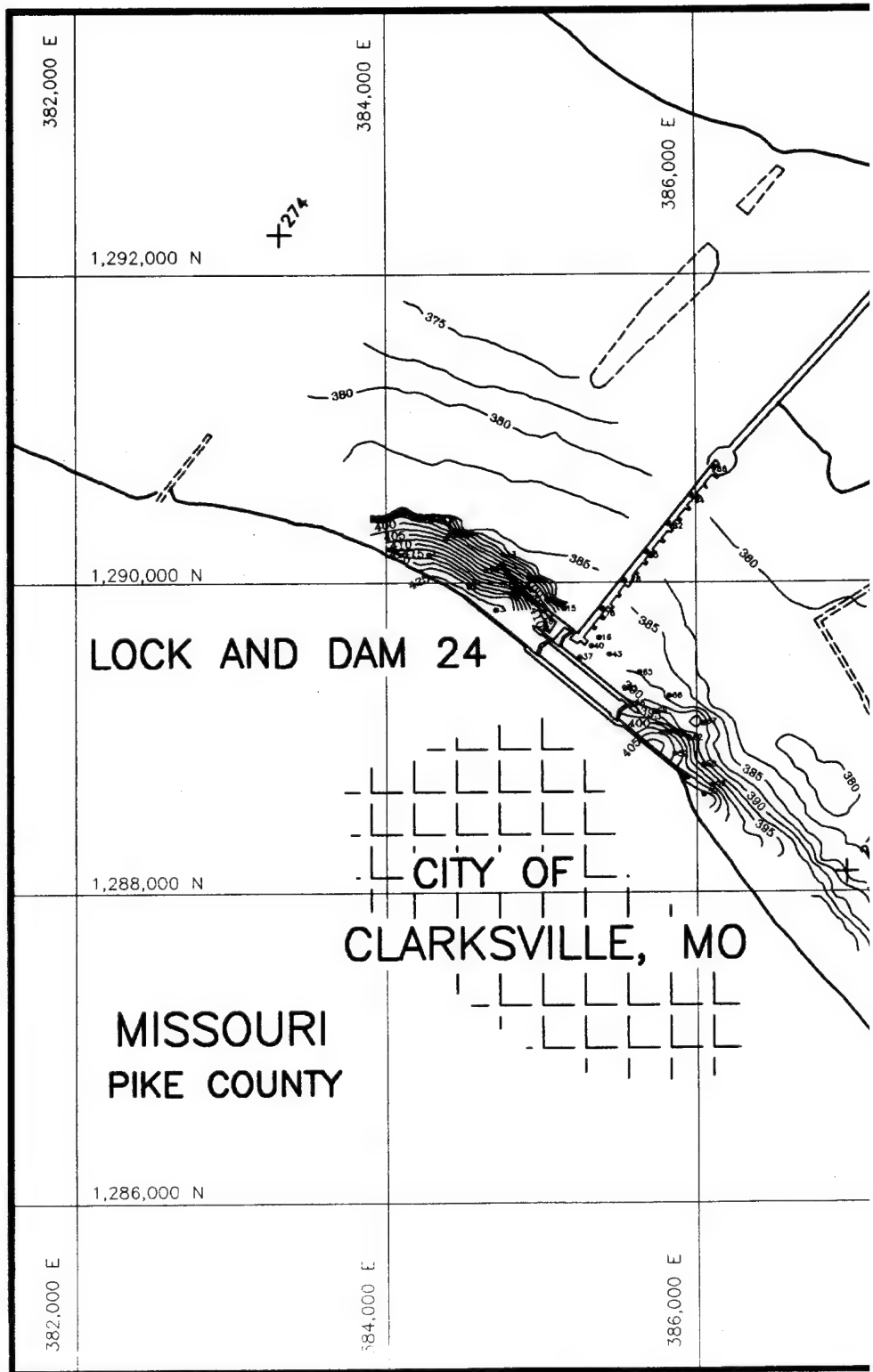
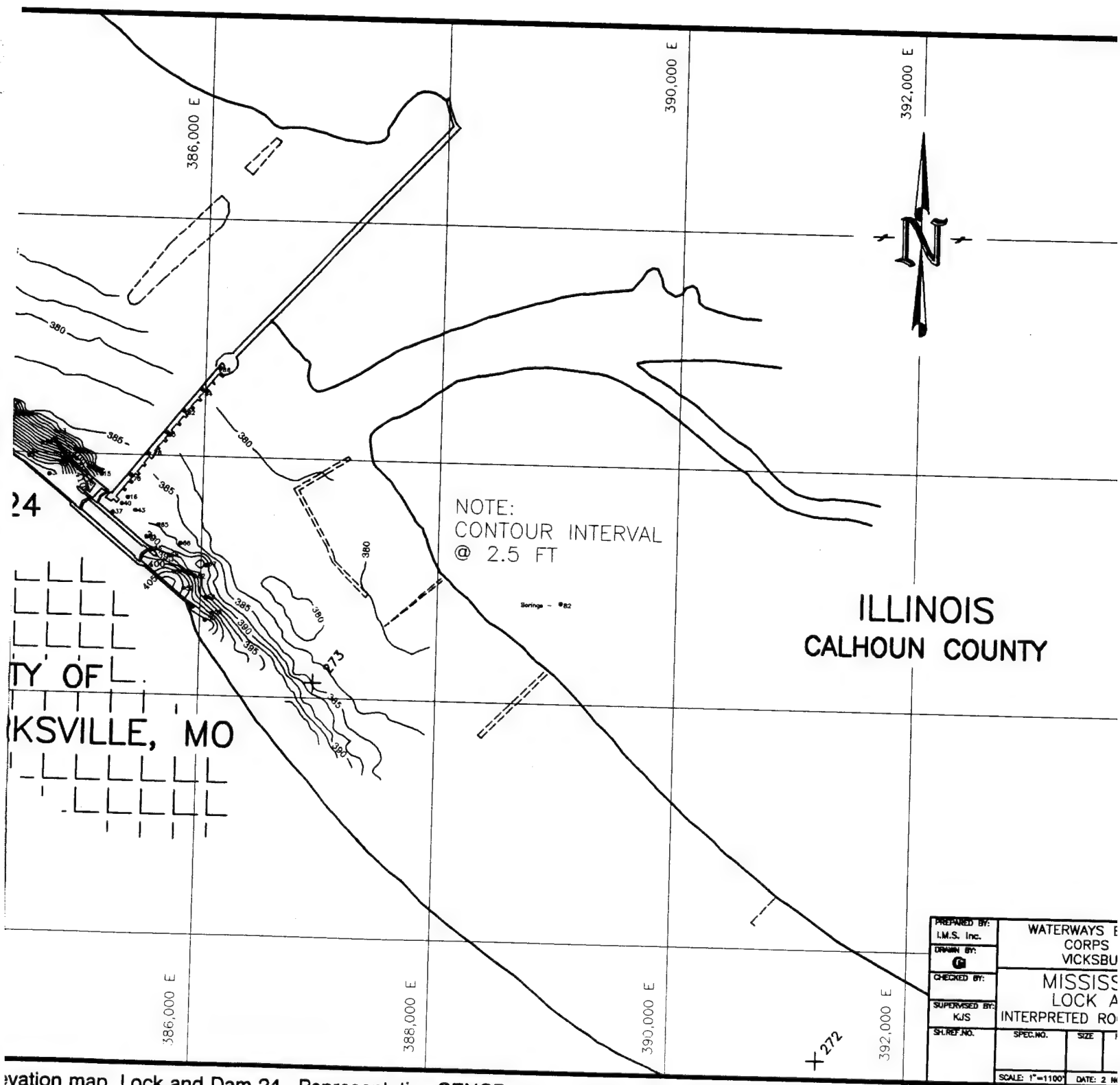
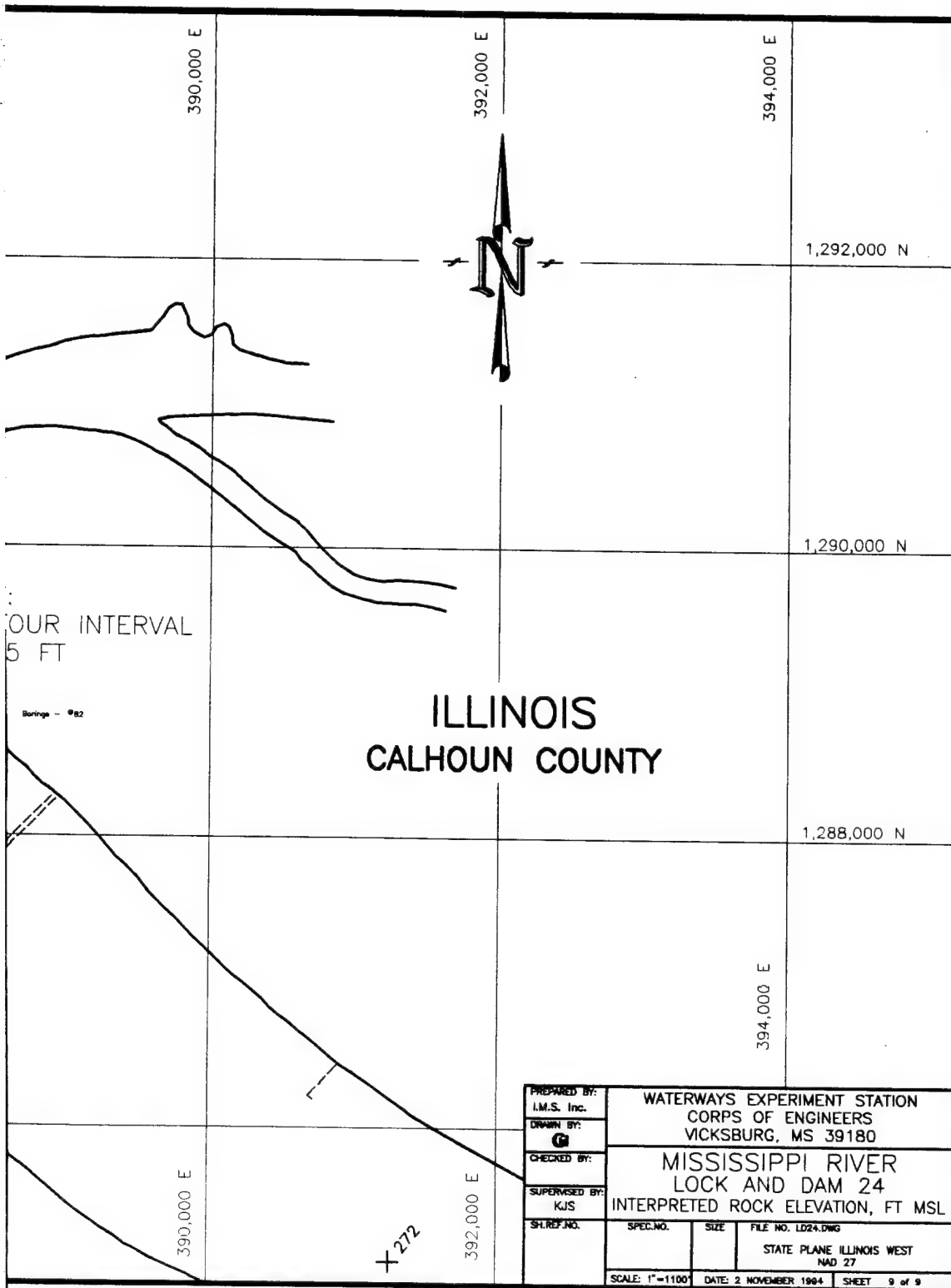


Figure 20. Interpreted rock surface elevation map, Lock and Dam 24. Re



Topographic map, Lock and Dam 24. Representative CENCRC core locations are also illustrated



core locations are also illustrated

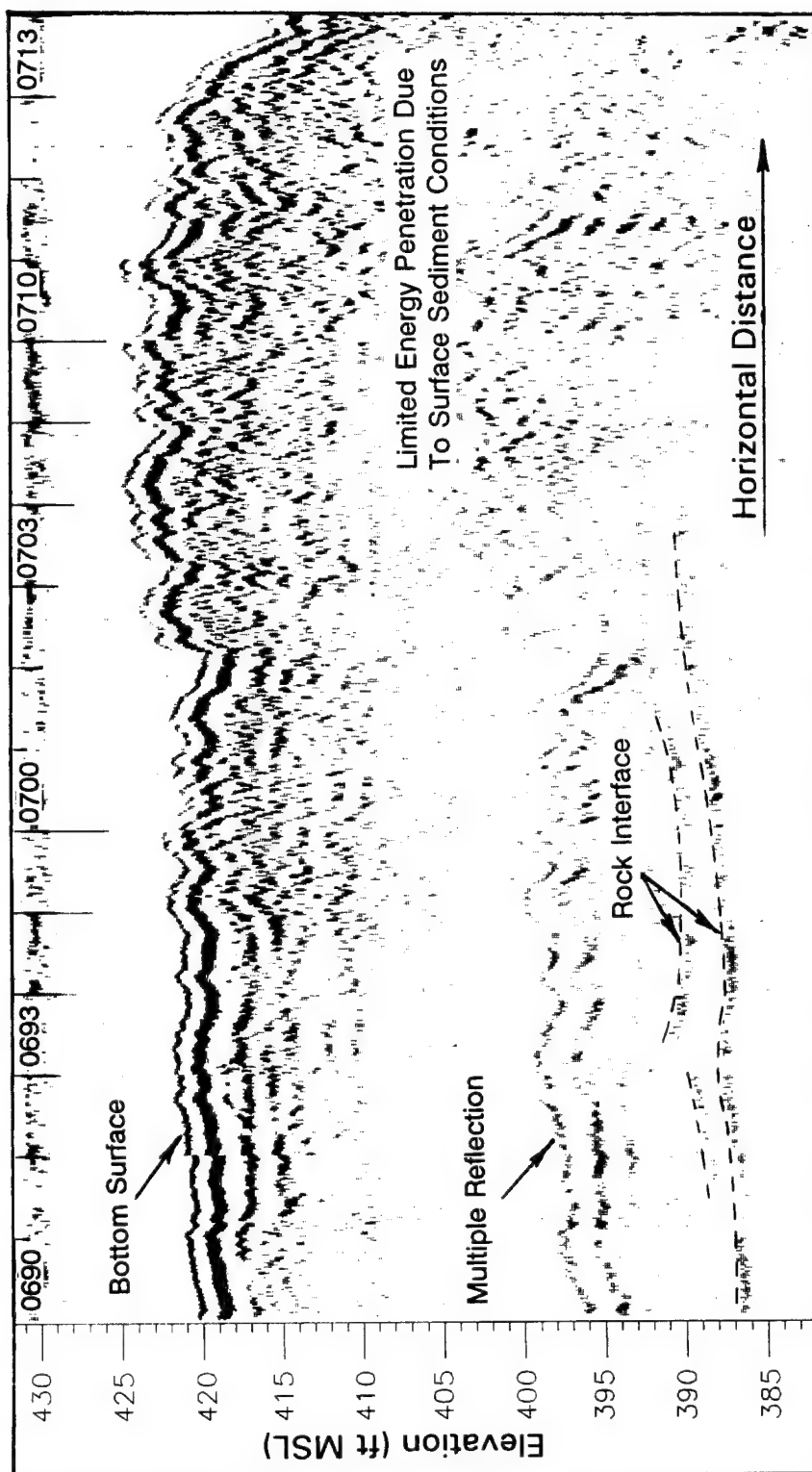


Figure 21. Subbottom seismic reflection record along 'boomer' survey line #4 (files 0690-0713), downstream of Lock and Dam 24

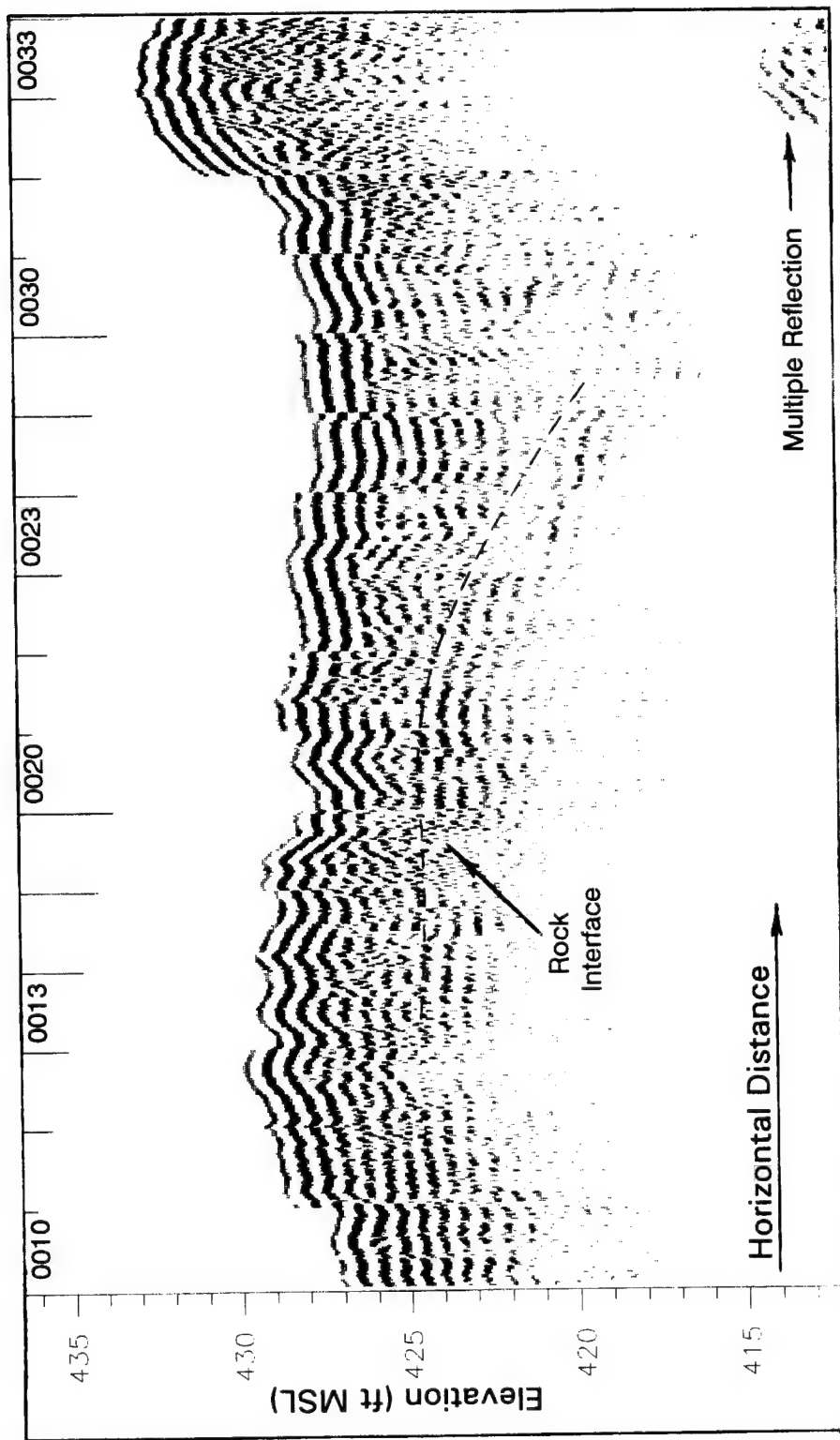


Figure 22. Subbottom seismic reflection record along 'pinger' survey line #26 (files 0010-0033), upstream of Lock and Dam 24

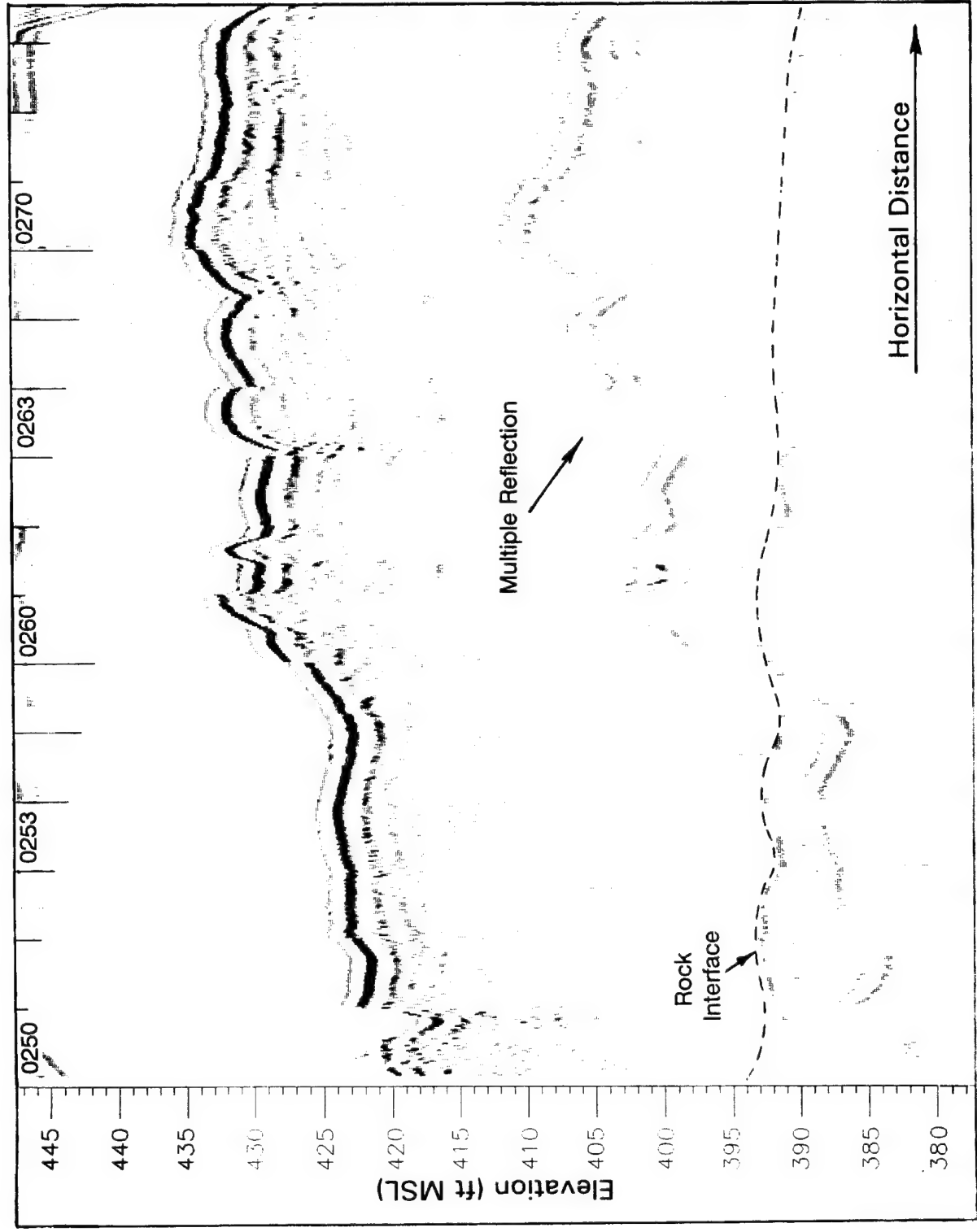


Figure 23. Subbottom seismic reflection record along 'boomer' survey line #35 (files 0250-0272), upstream of Lock and Dam 24

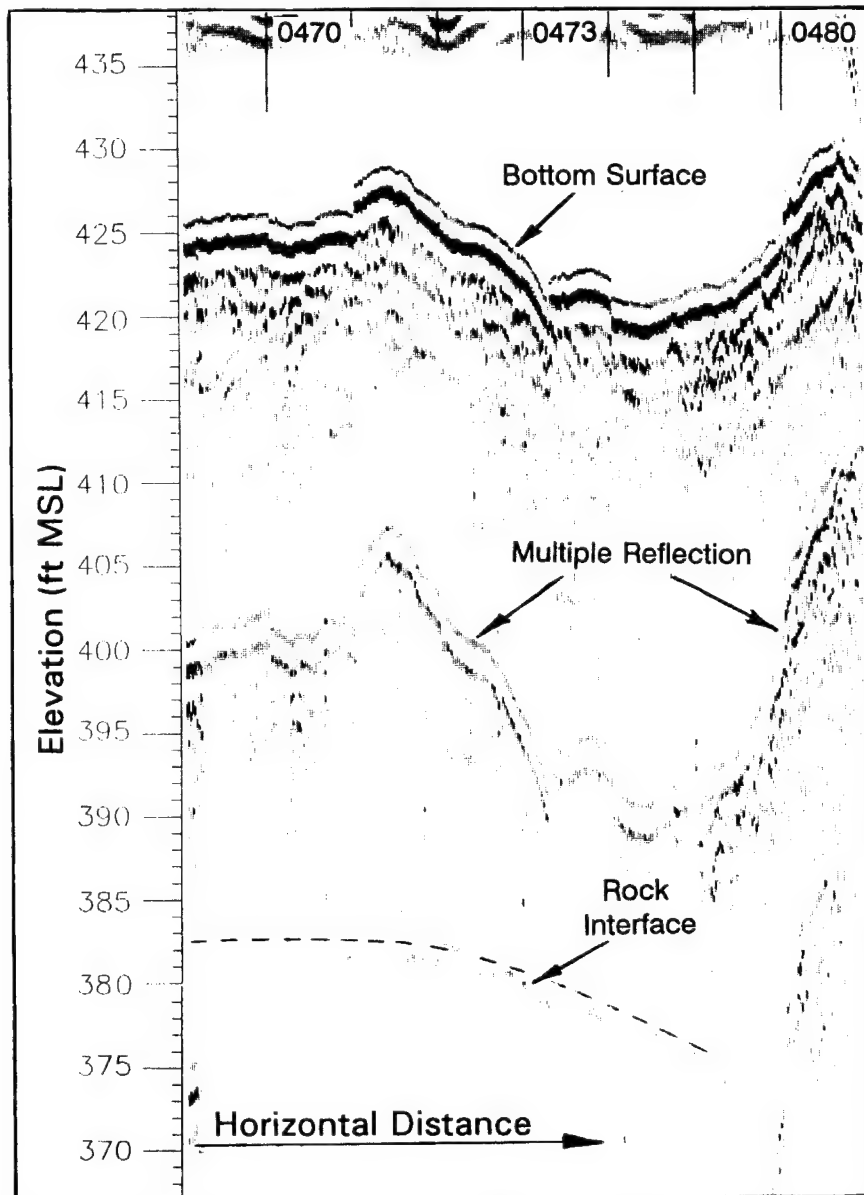


Figure 24. Subbottom seismic reflection record along 'boomer' survey line #75 (files 0464-0480), upstream of Lock and Dam 24

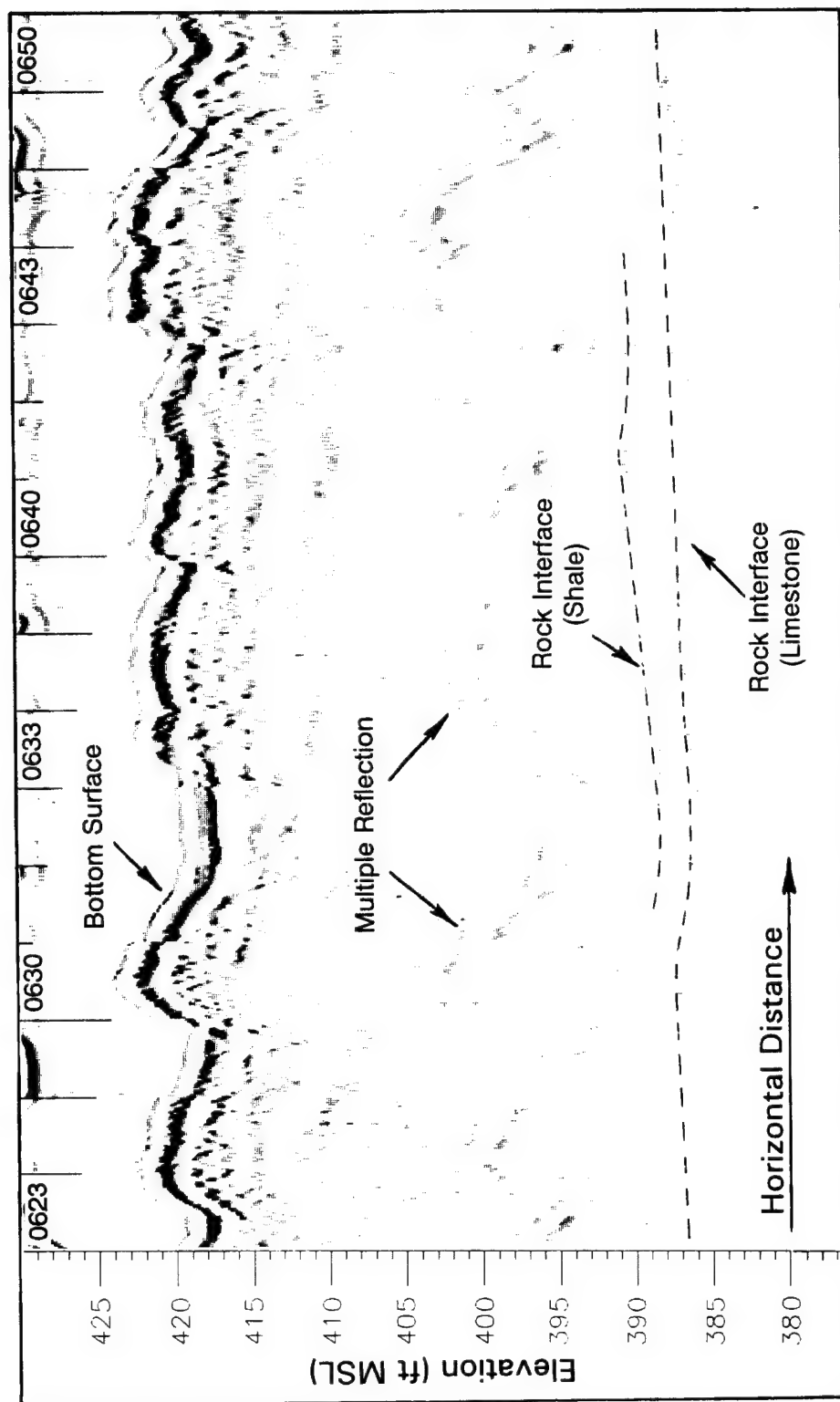


Figure 25. Subbottom seismic reflection record along 'boomer' survey line #3 (files 0623-0650), downstream of Lock and Dam 24

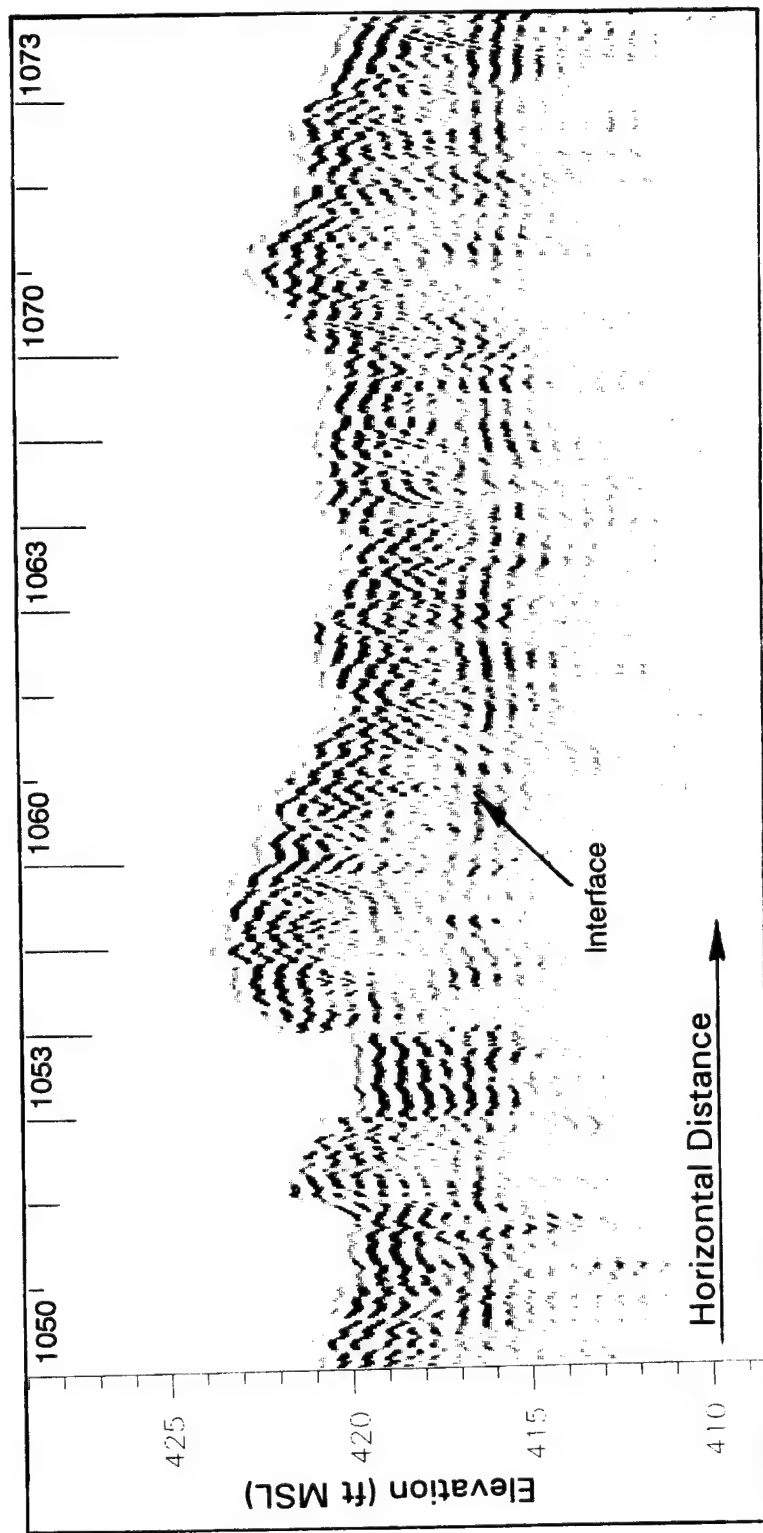


Figure 26. Subbottom seismic reflection record along 'pinger' survey line #3 (files 1050-1073), downstream of Lock and Dam 24

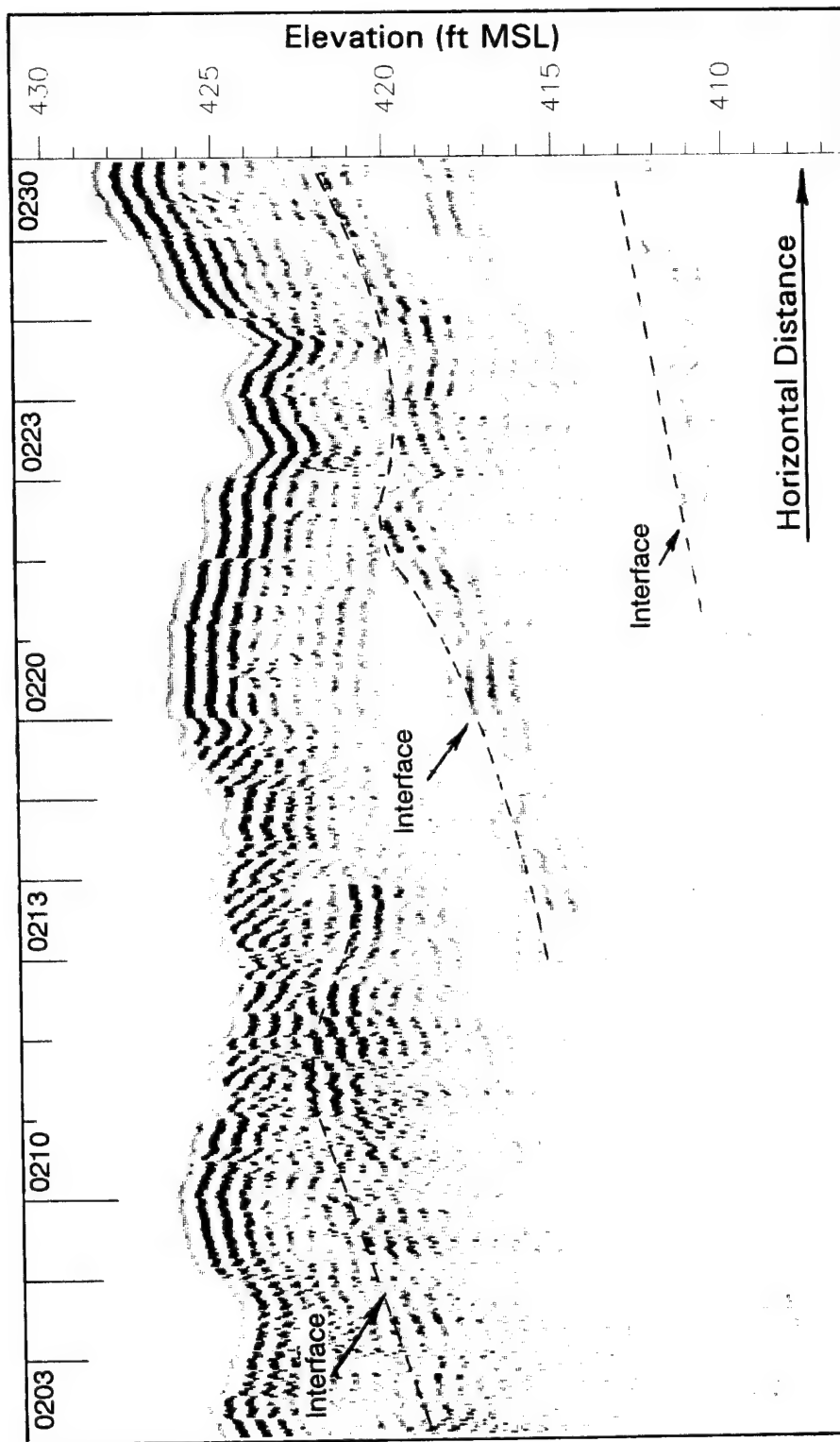


Figure 27. Subbottom seismic reflection record along 'pinger' survey line #30 (files 0203-0230), upstream of Lock and Dam 24

Appendix A

Lock and Dam 20 Positioning Information for the 'Pinger' Data

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
 Survey Date/Time : 25 July 1994, 0848 to 1325 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 476.4 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #1				
0000	123094	1266637	16.9	459.5
0003	123037	1266963	--	---
0010	123034	1267319	--	---
0013	123028	1267661	--	---
0020	123008	1268022	--	---
Survey Line #2				
0023	123170	1266317	18.2	458.2
0030	123152	1266650	19.1	457.3
0033	123148	1266993	19.7	456.7
0040	123102	1267332	20.9	455.5
0043	123112	1267690	18.7	457.7
0050	123098	1268064	18.2	458.2
Survey Line #3				
0053	123230	1266600	18.3	458.1
0060	123218	1266953	20.2	456.2
0063	123222	1267317	18.1	458.3
0070	123197	1267686	18.6	457.8
0073	123212	1268087	18.9	457.5
0080	123185	1268544	17.4	459.0
Survey Line #4				
0090	123319	1266265	18.5	457.9
0093	123311	1266588	21.1	455.3
0100	123325	1266936	19.0	457.4
0103	123317	1267296	18.3	458.1
0110	123306	1267663	20.0	456.4
0113	123284	1268038	18.6	457.8
0120	123281	1268413	20.4	456.0

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
 Survey Date/Time : 25 July 1994, 0848 to 1325 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 476.4 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #5				
0130	123429	1266117	22.2	454.2
0133	123460	1266456	24.0	452.4
0140	123438	1266793	22.6	453.8
0143	123432	1267148	21.4	455.0
0150	123421	1267502	23.2	453.2
0153	123390	1267861	22.6	453.8
0160	123445	1268237	29.9	446.5
0163	123408	1268640	31.8	444.6
Survey Line #6				
0170	123559	1265928	25.9	450.5
0173	123544	1266217	25.1	451.3
0180	123516	1266506	23.3	453.1
0183	123527	1266812	22.2	454.2
0190	123505	1267143	21.5	454.9
0193	123533	1267474	25.3	451.1
0200	123517	1267838	27.4	449.0
0203	123493	1268189	30.9	445.5
0210	123505	1268575	33.1	443.3
Survey Line #7				
0220	123654	1266180	25.5	450.9
0223	123627	1266458	24.5	451.9
0230	123637	1266745	24.1	452.3
0233	123632	1267061	24.5	451.9
0240	123610	1267336	26.1	450.3
0243	123633	1267594	28.1	448.3
0250	123601	1267885	30.9	445.5
0253	123571	1268244	30.2	446.2
0260	123617	1268648	33.5	442.9

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
 Survey Date/Time : 25 July 1994, 0848 to 1325 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 476.4 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #8				
0263	123741	1265947	24.6	451.8
0270	123751	1266211	23.6	452.8
0273	123727	1266482	23.9	452.5
0280	123733	1266748	25.0	451.4
0283	123721	1267030	25.4	451.0
0290	123796	1267343	24.3	452.1
0293	123712	1267589	27.6	448.8
0300	123676	1267875	30.2	446.2
0303	123709	1268210	31.2	445.2
0310	123717	1268643	34.8	441.6
Survey Line #10				
0313	123939	1265925	24.2	452.2
0320	123945	1266184	22.1	454.3
0323	123932	1266499	23.0	453.4
0330	123922	1266810	25.9	450.5
0333	123895	1267121	25.5	450.9
0340	123914	1267415	23.0	453.4
0343	123885	1267737	24.9	451.5
0350	123907	1268053	25.0	451.4
0353	123956	1268372	25.2	451.2
0360	123927	1268814	29.2	447.2
Survey Line #12				
0363	124119	1266012	22.2	454.2
0370	124121	1266258	22.3	454.1
0373	124146	1266519	23.2	453.2
0380	124188	1266766	22.8	453.6
0383	124154	1267017	25.2	451.2
0390	124115	1267281	22.6	453.8
0393	124125	1267519	21.6	454.8
0400	124131	1267798	22.6	453.8
0403	124080	1268088	22.4	454.0
0410	124129	1268367	23.2	453.2

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
 Survey Date/Time : 25 July 1994, 0848 to 1325 hours
 Acoustic Source : 'Boomer' System operating at 500-2000 Hertz

Water Level Elevation : 476.4 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #14				
0420	124320	1266059	20.6	455.8
0423	124335	1266309	23.9	452.5
0430	124341	1266551	20.5	455.9
0433	124314	1266766	22.5	453.9
0440	124324	1266992	24.5	451.9
0443	124317	1267223	25.0	451.4
0450	124290	1267430	22.0	454.4
0453	124308	1267630	22.9	453.5
0460	124285	1267820	20.3	456.1
0463	124293	1268061	19.9	456.5
0470	124267	1268338	23.9	452.5
0473	124346	1268707	27.5	448.9
Survey Line #16				
0480	124524	1265949	18.4	458.0
0483	124503	1266150	20.7	455.7
0490	124581	1266342	19.9	456.5
0493	124559	1266478	18.4	458.0
0500	124520	1266541	19.5	456.9
0503	124524	1266680	19.1	457.3
0510	124567	1266819	18.9	457.5
0513	124569	1266994	22.1	454.3
0520	124526	1267107	24.0	452.4
0523	124502	1267231	25.8	450.6
0530	124543	1267362	23.6	452.8
0533	124473	1267516	26.1	450.3
0540	124488	1267701	24.5	451.9
0543	124455	1267872	23.3	453.1
0550	124522	1268106	27.0	449.4
0553	124489	1268435	23.6	452.8
0560	124434	1268894	25.9	450.5

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
Survey Date/Time : 25 July 1994, 0848 to 1325 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 476.4 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #18				
0563	124725	1266130	20.0	456.4
0570	124782	1266530	15.2	461.2
0573	124802	1266882	17.9	458.5
0580	124779	1267327	15.9	460.5
0583	124757	1267850	26.3	450.1
0590	124648	1268260	--	---
0593	124641	1268466	--	---
0600	124694	1268720	--	---

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : East
 Survey Date/Time : 25 July 1994, 1338 to 1507 hours
 Acoustic Source : 'Boomer' System operating at 500-2000 Hertz

Water Level Elevation : 476.4 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #50				
0610	123450	1266193	24.0	452.4
0613	123871	1266106	22.0	454.4
0620	124209	1266182	21.1	455.3
0623	124579	1266208	22.8	453.6
0630	124980	1266229	18.0	458.4
Survey Line #51				
0633	123170	1266563	19.9	456.5
0640	123584	1266601	24.3	452.1
0643	123992	1266612	23.9	452.5
0650	124395	1266627	22.4	454.0
0653	124843	1266612	15.7	460.7
Survey Line #52				
0660	123176	1266972	20.2	456.2
0663	123577	1267014	24.2	452.2
0670	124025	1267009	23.9	452.5
0673	124404	1267071	23.6	452.8
0680	124874	1266988	16.2	460.2
Survey Line #53				
0683	123182	1267368	18.2	458.2
0690	123655	1267373	26.2	450.2
0693	124057	1267412	21.0	455.4
0700	124431	1267424	25.6	450.8
0703	124812	1267376	17.7	458.7
Survey Line #54				
0710	123241	1267760	14.9	461.5
0713	123638	1267796	27.9	448.5
0720	124027	1267804	23.2	453.2
0723	124392	1267808	21.3	455.1
0730	124680	1267794	27.6	448.8

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : East
Survey Date/Time : 25 July 1994, 1338 to 1507 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 476.4 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #55				
0740	123536	1268231	31.4	445.0
0743	123946	1268237	22.5	453.9
0750	124334	1268241	23.5	452.9
0753	124669	1268215	19.6	456.8
Survey Line #56				
0763	123633	1268691	35.6	440.8
0770	124107	1268733	33.7	442.7
0773	124587	1268760	--	---

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
 Survey Date/Time : 24 July 1994, 1127 to 1508 hours
 Acoustic Source : 'Boomer' System operating at 500-2000 Hertz

Water Level Elevation : 479.0 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #25				
0033	123013	1269882	21.1	457.9
0040	122953	1270306	19.6	459.4
0043	122943	1270736	20.2	458.8
0050	122934	1271174	22.9	456.1
Survey Line #26				
0053	123125	1269684	19.7	459.3
0060	123164	1269967	27.9	451.1
0063	123142	1270248	27.1	451.9
0070	123097	1270530	25.4	453.6
0073	123096	1270829	25.9	453.1
0080	123126	1271151	26.6	452.4
Survey Line #27				
0000	123247	1269563	22.7	456.3
0003	123228	1269982	28.7	450.3
0010	123252	1270295	27.4	451.6
0013	123213	1270574	25.5	453.5
0020	123292	1270831	22.7	456.3
0023	123279	1271098	23.3	455.7
Survey Line #28				
0083	123188	1271468	23.9	455.1
0090	123376	1269750	32.5	446.5
0093	123376	1270079	27.0	452.0
0100	123349	1270411	22.7	456.3
0103	123397	1270739	21.3	457.7
0110	123359	1271062	21.4	457.6
Survey Line #29				
0113	123430	1271378	21.5	457.5
0120	123499	1269688	34.6	444.4
0123	123446	1270013	27.1	451.9
0130	123466	1270350	21.8	457.2
0133	123407	1270692	20.8	458.2
0140	123444	1271042	20.0	459.0

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
 Survey Date/Time : 24 July 1994, 1127 to 1508 hours
 Acoustic Source : 'Boomer' System operating at 500-2000 Hertz

Water Level Elevation : 479.0 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #30				
0143	123488	1271394	20.5	458.5
0150	123588	1269682	31.1	447.9
0153	123559	1270024	21.4	457.6
0160	123540	1270341	17.9	461.1
0163	123567	1270660	19.0	460.0
0170	123531	1270989	18.3	460.7
0173	123585	1271322	18.6	460.4
Survey Line #31				
0180	123680	1269537	29.3	449.7
0183	123651	1269864	23.4	455.6
0190	123666	1270179	18.5	460.5
0193	123611	1270514	17.8	461.2
0200	123659	1270837	16.9	462.1
0203	123647	1271161	17.9	461.1
Survey Line #32				
0210	123750	1269419	26.6	452.4
0213	123760	1269752	20.8	458.2
0220	123716	1270070	17.3	461.7
0223	123771	1270381	15.8	463.2
0230	123751	1270702	15.7	463.3
0233	123721	1271012	16.5	462.5
0240	123756	1271314	17.1	461.9
Survey Line #34				
0243	123984	1269486	18.2	460.8
0250	123961	1269794	16.1	462.9
0253	123944	1270094	14.6	464.4
0260	123962	1270396	16.0	463.0
0263	123915	1270683	14.4	464.6
0270	123945	1270972	16.8	462.2
0273	123975	1271257	16.7	462.3

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
 Survey Date/Time : 24 July 1994, 1127 to 1508 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 479.0 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #36				
0280	124138	1269399	23.0	456.0
0283	124150	1269727	17.8	461.2
0290	124176	1270020	14.2	464.8
0293	124148	1270315	14.3	464.7
0300	124167	1270598	13.4	465.6
0303	124148	1270871	13.6	465.4
0310	124158	1271146	15.3	463.7
Survey Line #38				
0320	124361	1269696	19.3	459.7
0323	124359	1270008	16.1	462.9
0330	124353	1270323	15.2	463.8
0333	124349	1270623	12.4	466.6
0340	124351	1270918	13.6	465.4
0343	124311	1271222	15.1	463.9
Survey Line #40				
0350	124552	1269392	26.0	453.0
0353	124542	1269704	23.8	455.2
0360	124579	1270029	18.4	460.6
0363	124562	1270352	14.9	464.1
0370	124584	1270657	16.1	462.9
0373	124563	1270970	13.3	465.7
0380	124502	1271269	15.7	463.3
Survey Line #42				
0383	124748	1269490	24.2	454.8
0390	124727	1269798	25.1	453.9
0393	124768	1270100	23.2	455.8
0400	124743	1270416	18.1	460.9
0403	124750	1270731	16.9	462.1
0410	124805	1271047	12.7	466.3

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
Survey Date/Time : 24 July 1994, 1127 to 1508 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 479.0 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #44				
0410	124805	1271047	12.7	466.3
0413	124708	1271373	14.6	464.4
0420	124946	1269605	21.2	457.8
0423	124906	1269909	25.3	453.7
0430	124934	1270206	24.8	454.2
0433	124923	1270499	20.8	458.2
0440	124891	1270803	18.9	460.1
0443	124963	1271144	13.0	466.0
Survey Line #46				
0450	124790	1271406	14.5	464.5
0453	125145	1269807	17.8	461.2
0460	125146	1270126	20.3	458.7
0463	125138	1270436	22.2	456.8
0470	125181	1270744	22.1	456.9
0473	125262	1271038	20.0	459.0
0480	125282	1271350	17.2	461.8

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : East
 Survey Date/Time : 24 July 1994, 1516 to 1651 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 479.0 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #61				
0483	123659	1269291	28.5	450.5
0490	124145	1269278	25.9	453.1
0493	124619	1269266	25.1	453.9
0500	125060	1269270	16.5	462.5
Survey Line #62				
0500	125060	1269270	16.5	462.5
0503	123602	1269463	30.3	448.7
0510	124201	1269447	21.8	457.2
0513	124732	1269458	23.7	455.3
Survey Line #63				
0520	125184	1269546	14.3	464.7
0523	123959	1269690	17.7	461.3
0530	124494	1269641	23.8	455.2
0533	124942	1269630	21.0	458.0
Survey Line #64				
0540	125183	1269791	15.5	463.5
0543	123579	1270042	19.3	459.7
0550	123996	1270123	15.0	464.0
0553	124449	1270040	17.9	461.1
0560	124853	1270065	27.1	451.9
0563	125199	1270131	19.1	459.9
Survey Line #65				
0570	123275	1270438	22.8	456.2
0573	123709	1270452	15.8	463.2
0580	124154	1270433	14.5	464.5
0583	124554	1270490	15.2	463.8
0590	124949	1270509	21.5	457.5
Survey Line #66				
0600	123456	1270823	19.0	460.0
0603	123887	1270820	15.2	463.8
0610	124299	1270834	13.0	466.0

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : East
Survey Date/Time : 24 July 1994, 1516 to 1651 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 479.0 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #66 cont.				
0613	124700	1270857	17.2	461.8
0620	125110	1270837	21.3	457.7
Survey Line #67				
0623	123282	1271133	22.2	456.8
0630	123666	1271197	17.0	462.0
0633	124047	1271233	14.6	464.4
0640	124418	1271260	15.5	463.5
0643	124782	1271310	13.5	465.5
0650	125193	1271288	18.7	460.3

Appendix B

Lock and Dam 20 Positioning Information for the 'Boomer' Data

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
Survey Date/Time : 25 July 1994, 0848 to 1325 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 476.4 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #1				
0000	123094	1266637	16.9	459.5
0003	123037	1266963	--	---
0010	123034	1267319	--	---
0013	123028	1267661	--	---
0020	123008	1268022	--	---
Survey Line #2				
0023	123170	1266317	18.2	458.2
0030	123152	1266650	19.1	457.3
0033	123148	1266993	19.7	456.7
0040	123102	1267332	20.9	455.5
0043	123112	1267690	18.7	457.7
0050	123098	1268064	18.2	458.2
Survey Line #3				
0053	123230	1266600	18.3	458.1
0060	123218	1266953	20.2	456.2
0063	123222	1267317	18.1	458.3
0070	123197	1267686	18.6	457.8
0073	123212	1268087	18.9	457.5
0080	123185	1268544	17.4	459.0
Survey Line #4				
0090	123319	1266265	18.5	457.9
0093	123311	1266588	21.1	455.3
0100	123325	1266936	19.0	457.4
0103	123317	1267296	18.3	458.1
0110	123306	1267663	20.0	456.4
0113	123284	1268038	18.6	457.8
0120	123281	1268413	20.4	456.0

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
Survey Date/Time : 25 July 1994, 0848 to 1325 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 476.4 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #5				
0130	123429	1266117	22.2	454.2
0133	123460	1266456	24.0	452.4
0140	123438	1266793	22.6	453.8
0143	123432	1267148	21.4	455.0
0150	123421	1267502	23.2	453.2
0153	123390	1267861	22.6	453.8
0160	123445	1268237	29.9	446.5
0163	123408	1268640	31.8	444.6
Survey Line #6				
0170	123559	1265928	25.9	450.5
0173	123544	1266217	25.1	451.3
0180	123516	1266506	23.3	453.1
0183	123527	1266812	22.2	454.2
0190	123505	1267143	21.5	454.9
0193	123533	1267474	25.3	451.1
0200	123517	1267838	27.4	449.0
0203	123493	1268189	30.9	445.5
0210	123505	1268575	33.1	443.3
Survey Line #7				
0220	123654	1266180	25.5	450.9
0223	123627	1266458	24.5	451.9
0230	123637	1266745	24.1	452.3
0233	123632	1267061	24.5	451.9
0240	123610	1267336	26.1	450.3
0243	123633	1267594	28.1	448.3
0250	123601	1267885	30.9	445.5
0253	123571	1268244	30.2	446.2
0260	123617	1268648	33.5	442.9

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
 Survey Date/Time : 25 July 1994, 0848 to 1325 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 476.4 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #8				
0263	123741	1265947	24.6	451.8
0270	123751	1266211	23.6	452.8
0273	123727	1266482	23.9	452.5
0280	123733	1266748	25.0	451.4
0283	123721	1267030	25.4	451.0
0290	123796	1267343	24.3	452.1
0293	123712	1267589	27.6	448.8
0300	123676	1267875	30.2	446.2
0303	123709	1268210	31.2	445.2
0310	123717	1268643	34.8	441.6
Survey Line #10				
0313	123939	1265925	24.2	452.2
0320	123945	1266184	22.1	454.3
0323	123932	1266499	23.0	453.4
0330	123922	1266810	25.9	450.5
0333	123895	1267121	25.5	450.9
0340	123914	1267415	23.0	453.4
0343	123885	1267737	24.9	451.5
0350	123907	1268053	25.0	451.4
0353	123956	1268372	25.2	451.2
0360	123927	1268814	29.2	447.2
Survey Line #12				
0363	124119	1266012	22.2	454.2
0370	124121	1266258	22.3	454.1
0373	124146	1266519	23.2	453.2
0380	124188	1266766	22.8	453.6
0383	124154	1267017	25.2	451.2
0390	124115	1267281	22.6	453.8
0393	124125	1267519	21.6	454.8
0400	124131	1267798	22.6	453.8
0403	124080	1268088	22.4	454.0
0410	124129	1268367	23.2	453.2

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
 Survey Date/Time : 25 July 1994, 0848 to 1325 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 476.4 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #14				
0420	124320	1266059	20.6	455.8
0423	124335	1266309	23.9	452.5
0430	124341	1266551	20.5	455.9
0433	124314	1266766	22.5	453.9
0440	124324	1266992	24.5	451.9
0443	124317	1267223	25.0	451.4
0450	124290	1267430	22.0	454.4
0453	124308	1267630	22.9	453.5
0460	124285	1267820	20.3	456.1
0463	124293	1268061	19.9	456.5
0470	124267	1268338	23.9	452.5
0473	124346	1268707	27.5	448.9
Survey Line #16				
0480	124524	1265949	18.4	458.0
0483	124503	1266150	20.7	455.7
0490	124581	1266342	19.9	456.5
0493	124559	1266478	18.4	458.0
0500	124520	1266541	19.5	456.9
0503	124524	1266680	19.1	457.3
0510	124567	1266819	18.9	457.5
0513	124569	1266994	22.1	454.3
0520	124526	1267107	24.0	452.4
0523	124502	1267231	25.8	450.6
0530	124543	1267362	23.6	452.8
0533	124473	1267516	26.1	450.3
0540	124488	1267701	24.5	451.9
0543	124455	1267872	23.3	453.1
0550	124522	1268106	27.0	449.4
0553	124489	1268435	23.6	452.8
0560	124434	1268894	25.9	450.5

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
Survey Date/Time : 25 July 1994, 0848 to 1325 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 476.4 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #18				
0563	124725	1266130	20.0	456.4
0570	124782	1266530	15.2	461.2
0573	124802	1266882	17.9	458.5
0580	124779	1267327	15.9	460.5
0583	124757	1267850	26.3	450.1
0590	124648	1268260	--	---
0593	124641	1268466	--	---
0600	124694	1268720	--	---

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : East
Survey Date/Time : 25 July 1994, 1338 to 1507 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 476.4 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #50				
0610	123450	1266193	24.0	452.4
0613	123871	1266106	22.0	454.4
0620	124209	1266182	21.1	455.3
0623	124579	1266208	22.8	453.6
0630	124980	1266229	18.0	458.4
Survey Line #51				
0633	123170	1266563	19.9	456.5
0640	123584	1266601	24.3	452.1
0643	123992	1266612	23.9	452.5
0650	124395	1266627	22.4	454.0
0653	124843	1266612	15.7	460.7
Survey Line #52				
0660	123176	1266972	20.2	456.2
0663	123577	1267014	24.2	452.2
0670	124025	1267009	23.9	452.5
0673	124404	1267071	23.6	452.8
0680	124874	1266988	16.2	460.2
Survey Line #53				
0683	123182	1267368	18.2	458.2
0690	123655	1267373	26.2	450.2
0693	124057	1267412	21.0	455.4
0700	124431	1267424	25.6	450.8
0703	124812	1267376	17.7	458.7
Survey Line #54				
0710	123241	1267760	14.9	461.5
0713	123638	1267796	27.9	448.5
0720	124027	1267804	23.2	453.2
0723	124392	1267808	21.3	455.1
0730	124680	1267794	27.6	448.8

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : East
Survey Date/Time : 25 July 1994, 1338 to 1507 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 476.4 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #55				
0740	123536	1268231	31.4	445.0
0743	123946	1268237	22.5	453.9
0750	124334	1268241	23.5	452.9
0753	124669	1268215	19.6	456.8
Survey Line #56				
0763	123633	1268691	35.6	440.8
0770	124107	1268733	33.7	442.7
0773	124587	1268760	--	---

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
 Survey Date/Time : 24 July 1994, 1127 to 1508 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 479.0 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #25				
0033	123013	1269882	21.1	457.9
0040	122953	1270306	19.6	459.4
0043	122943	1270736	20.2	458.8
0050	122934	1271174	22.9	456.1
Survey Line #26				
0053	123125	1269684	19.7	459.3
0060	123164	1269967	27.9	451.1
0063	123142	1270248	27.1	451.9
0070	123097	1270530	25.4	453.6
0073	123096	1270829	25.9	453.1
0080	123126	1271151	26.6	452.4
Survey Line #27				
0000	123247	1269563	22.7	456.3
0003	123228	1269982	28.7	450.3
0010	123252	1270295	27.4	451.6
0013	123213	1270574	25.5	453.5
0020	123292	1270831	22.7	456.3
0023	123279	1271098	23.3	455.7
Survey Line #28				
0083	123188	1271468	23.9	455.1
0090	123376	1269750	32.5	446.5
0093	123376	1270079	27.0	452.0
0100	123349	1270411	22.7	456.3
0103	123397	1270739	21.3	457.7
0110	123359	1271062	21.4	457.6
Survey Line #29				
0113	123430	1271378	21.5	457.5
0120	123499	1269688	34.6	444.4
0123	123446	1270013	27.1	451.9
0130	123466	1270350	21.8	457.2
0133	123407	1270692	20.8	458.2
0140	123444	1271042	20.0	459.0

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
 Survey Date/Time : 24 July 1994, 1127 to 1508 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 479.0 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #30				
0143	123488	1271394	20.5	458.5
0150	123588	1269682	31.1	447.9
0153	123559	1270024	21.4	457.6
0160	123540	1270341	17.9	461.1
0163	123567	1270660	19.0	460.0
0170	123531	1270989	18.3	460.7
0173	123585	1271322	18.6	460.4
Survey Line #31				
0180	123680	1269537	29.3	449.7
0183	123651	1269864	23.4	455.6
0190	123666	1270179	18.5	460.5
0193	123611	1270514	17.8	461.2
0200	123659	1270837	16.9	462.1
0203	123647	1271161	17.9	461.1
Survey Line #32				
0210	123750	1269419	26.6	452.4
0213	123760	1269752	20.8	458.2
0220	123716	1270070	17.3	461.7
0223	123771	1270381	15.8	463.2
0230	123751	1270702	15.7	463.3
0233	123721	1271012	16.5	462.5
0240	123756	1271314	17.1	461.9
Survey Line #34				
0243	123984	1269486	18.2	460.8
0250	123961	1269794	16.1	462.9
0253	123944	1270094	14.6	464.4
0260	123962	1270396	16.0	463.0
0263	123915	1270683	14.4	464.6
0270	123945	1270972	16.8	462.2
0273	123975	1271257	16.7	462.3

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
 Survey Date/Time : 24 July 1994, 1127 to 1508 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 479.0 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #36				
0280	124138	1269399	23.0	456.0
0283	124150	1269727	17.8	461.2
0290	124176	1270020	14.2	464.8
0293	124148	1270315	14.3	464.7
0300	124167	1270598	13.4	465.6
0303	124148	1270871	13.6	465.4
0310	124158	1271146	15.3	463.7
Survey Line #38				
0320	124361	1269696	19.3	459.7
0323	124359	1270008	16.1	462.9
0330	124353	1270323	15.2	463.8
0333	124349	1270623	12.4	466.6
0340	124351	1270918	13.6	465.4
0343	124311	1271222	15.1	463.9
Survey Line #40				
0350	124552	1269392	26.0	453.0
0353	124542	1269704	23.8	455.2
0360	124579	1270029	18.4	460.6
0363	124562	1270352	14.9	464.1
0370	124584	1270657	16.1	462.9
0373	124563	1270970	13.3	465.7
0380	124502	1271269	15.7	463.3
Survey Line #42				
0383	124748	1269490	24.2	454.8
0390	124727	1269798	25.1	453.9
0393	124768	1270100	23.2	455.8
0400	124743	1270416	18.1	460.9
0403	124750	1270731	16.9	462.1
0410	124805	1271047	12.7	466.3

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : North (Upstream)
Survey Date/Time : 24 July 1994, 1127 to 1508 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 479.0 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #44				
0410	124805	1271047	12.7	466.3
0413	124708	1271373	14.6	464.4
0420	124946	1269605	21.2	457.8
0423	124906	1269909	25.3	453.7
0430	124934	1270206	24.8	454.2
0433	124923	1270499	20.8	458.2
0440	124891	1270803	18.9	460.1
0443	124963	1271144	13.0	466.0
Survey Line #46				
0450	124790	1271406	14.5	464.5
0453	125145	1269807	17.8	461.2
0460	125146	1270126	20.3	458.7
0463	125138	1270436	22.2	456.8
0470	125181	1270744	22.1	456.9
0473	125262	1271038	20.0	459.0
0480	125282	1271350	17.2	461.8

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : East
 Survey Date/Time : 24 July 1994, 1516 to 1651 hours
 Acoustic Source : 'Boomer' System operating at 500-2000 Hertz

Water Level Elevation : 479.0 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #61				
0483	123659	1269291	28.5	450.5
0490	124145	1269278	25.9	453.1
0493	124619	1269266	25.1	453.9
0500	125060	1269270	16.5	462.5
Survey Line #62				
0500	125060	1269270	16.5	462.5
0503	123602	1269463	30.3	448.7
0510	124201	1269447	21.8	457.2
0513	124732	1269458	23.7	455.3
Survey Line #63				
0520	125184	1269546	14.3	464.7
0523	123959	1269690	17.7	461.3
0530	124494	1269641	23.8	455.2
0533	124942	1269630	21.0	458.0
Survey Line #64				
0540	125183	1269791	15.5	463.5
0543	123579	1270042	19.3	459.7
0550	123996	1270123	15.0	464.0
0553	124449	1270040	17.9	461.1
0560	124853	1270065	27.1	451.9
0563	125199	1270131	19.1	459.9
Survey Line #65				
0570	123275	1270438	22.8	456.2
0573	123709	1270452	15.8	463.2
0580	124154	1270433	14.5	464.5
0583	124554	1270490	15.2	463.8
0590	124949	1270509	21.5	457.5
Survey Line #66				
0600	123456	1270823	19.0	460.0
0603	123887	1270820	15.2	463.8
0610	124299	1270834	13.0	466.0

**Lock and Dam 20
Upper Mississippi River**

Survey Direction : East
Survey Date/Time : 24 July 1994, 1516 to 1651 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 479.0 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #66 cont.				
0613	124700	1270857	17.2	461.8
0620	125110	1270837	21.3	457.7
Survey Line #67				
0623	123282	1271133	22.2	456.8
0630	123666	1271197	17.0	462.0
0633	124047	1271233	14.6	464.4
0640	124418	1271260	15.5	463.5
0643	124782	1271310	13.5	465.5
0650	125193	1271288	18.7	460.3

Appendix C

Lock and Dam 22 Positioning Information for the 'Pinger' Data

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
Survey Date/Time : 23 July 1994, 0904 to 1304 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 455.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #3				
0000	196869	1080625	13.0	442.0
0003	196786	1080750	--	---
0010	196691	1080868	14.8	440.2
0013	196606	1080984	13.0	442.0
0020	196517	1081084	14.1	440.9
0023	196430	1081194	16.2	438.8
0030	196344	1081303	16.0	439.0
0033	196249	1081440	15.7	439.3
0040	196139	1081579	15.8	439.2
0043	196026	1081718	16.6	438.4
0050	195899	1081877	16.5	438.5
Survey Line #4				
0060	196966	1080652	15.4	439.6
0063	196849	1080804	16.2	438.8
0070	196746	1080955	14.6	440.4
0073	196636	1081095	16.2	438.8
0080	196534	1081240	17.1	437.9
0083	196433	1081385	17.8	437.2
0090	196325	1081528	18.3	436.7
0093	196211	1081669	17.7	437.3
0100	196094	1081812	18.2	436.8
0103	195999	1081970	21.0	434.0
0110	195900	1082131	19.1	435.9
0113	195818	1082307	--	---
0120	195694	1082492	17.0	438.0
0123	195529	1082752	15.7	439.3
Survey Line #5				
0130	197046	1080710	17.1	437.9
0133	196927	1080876	17.5	437.5
0140	196800	1081036	16.6	438.4
0143	196699	1081211	19.1	435.9
0150	196590	1081394	18.4	436.6
0153	196448	1081568	16.5	438.5
0160	196299	1081736	17.7	437.3
0163	196147	1081917	19.2	435.8

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
 Survey Date/Time : 23 July 1994, 0904 to 1304 hours
 Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 455.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #5 cont.				
0170	196003	1082132	20.4	434.6
0173	195876	1082418	22.9	432.1
0180	195728	1082649	18.5	436.5
0183	195557	1082905	19.0	436.0
Survey Line #6				
0190	197122	1080792	17.7	437.3
0193	196967	1080965	18.2	436.8
0200	196838	1081161	17.8	437.2
0203	196697	1081349	18.1	436.9
0210	196568	1081536	18.2	436.8
0213	196411	1081734	18.7	436.3
0220	196274	1081935	20.4	434.6
0223	196144	1082177	21.7	433.3
0230	196028	1082430	23.5	431.5
0233	195853	1082643	21.5	433.5
0240	195705	1082859	20.2	434.8
Survey Line #7				
0243	197230	1080795	16.8	438.2
0250	197098	1080933	17.1	437.9
0253	196993	1081113	17.5	437.5
0260	196864	1081316	17.0	438.0
0263	196683	1081502	18.9	436.1
0270	196527	1081725	20.7	434.3
0273	196416	1081989	21.5	433.5
0280	196279	1082221	22.3	432.7
0283	196143	1082459	23.9	431.1
0290	195988	1082670	21.7	433.3
0293	195849	1082888	21.0	434.0
Survey Line #8				
0300	197342	1080871	16.2	438.8
0303	197241	1081042	16.2	438.8
0310	197110	1081210	17.3	437.7
0313	196957	1081389	19.1	435.9

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
Survey Date/Time : 23 July 1994, 0904 to 1304 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 455.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #8 cont.				
0320	196796	1081588	21.3	433.7
0323	196644	1081794	22.2	432.8
0330	196530	1081991	22.1	432.9
0333	196421	1082184	22.3	432.7
0340	196254	1082407	23.2	431.8
0343	196136	1082627	24.0	431.0
0350	195896	1082816	22.5	432.5
Survey Line #9				
0353	197358	1080918	24.6	430.4
0360	197306	1081066	16.0	439.0
0363	197159	1081186	17.6	437.4
0370	197054	1081368	20.3	434.7
0373	196923	1081578	24.0	431.0
0380	196805	1081807	23.6	431.4
0383	196685	1082001	23.4	431.6
0390	196513	1082151	22.5	432.5
0393	196340	1082398	23.6	431.4
0400	196234	1082698	24.2	430.8
0403	195998	1082944	--	---
Survey Line #10				
0410	197462	1080999	24.2	430.8
0413	197355	1081192	17.5	437.5
0420	197182	1081329	20.1	434.9
0423	197032	1081524	24.3	430.7
0430	196947	1081768	24.3	430.7
0433	196860	1081924	23.9	431.1
0440	196778	1082073	24.9	430.1
0443	196654	1082250	24.2	430.8
0450	196474	1082456	22.7	432.3
0453	196270	1082687	23.3	431.7
0460	196050	1082960	24.8	430.2
Survey Line #11				
0463	197548	1081034	24.2	430.8
0470	197458	1081216	19.7	435.3

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
Survey Date/Time : 23 July 1994, 0904 to 1304 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 455.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>	
Survey Line #11 cont.					
0473	197299	1081396	21.0	434.0	
0480	197138	1081602	24.8	430.2	
0483	196999	1081866	24.4	430.6	
0490	196846	1082131	24.8	430.2	
0493	196638	1082354	23.0	432.0	
0500	196471	1082586	23.3	431.7	0493
196638	1082354	23.0		432.0	
0500	196471	1082586	23.3	431.7	
0503	196340	1082773	23.7	431.3	
0510	196214	1083018	25.2	429.8	
0513	195994	1083171	25.7	429.3	
Survey Line #12					
0520	197599	1081150	21.4	433.6	
0523	197468	1081344	22.2	432.8	
0530	197344	1081592	25.3	429.7	
0533	197165	1081835	24.6	430.4	
0540	196914	1082072	23.8	431.2	
0543	196749	1082318	23.1	431.9	
0550	196612	1082550	24.0	431.0	
0553	196478	1082823	25.5	429.5	
0560	196312	1082997	27.3	427.7	
Survey Line #13					
0563	196164	1083126	5.4	449.6	
0570	197667	1081256	19.6	435.4	
0573	197444	1081508	25.0	430.0	
0580	197241	1081756	23.6	431.4	
0583	197098	1082036	25.8	429.2	
0590	196953	1082277	26.1	428.9	
0593	196807	1082455	25.3	429.7	
0600	196655	1082683	22.9	432.1	
0603	196527	1082931	26.1	428.9	
0610	196447	1083092	28.2	426.8	
0613	196307	1083245	27.3	427.7	

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
Survey Date/Time : 23 July 1994, 0904 to 1304 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 455.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #14				
0623	197658	1081376	21.4	433.6
0630	197482	1081569	26.3	428.7
0633	197332	1081812	26.2	428.8
0640	197232	1082070	26.7	428.3
0643	197058	1082305	27.2	427.8
0650	196945	1082527	26.9	428.1
0653	196807	1082673	26.7	428.3
0660	196710	1082812	25.1	429.9
0663	196619	1082973	27.1	427.9
0670	196450	1083169	29.3	425.7
0673	196248	1083400	29.5	425.5
Survey Line #15				
0680	197846	1081300	19.9	435.1
0683	197719	1081485	24.9	430.1
0690	197576	1081702	24.8	430.2
0693	197428	1081958	25.4	429.6
0700	197262	1082219	26.0	429.0
0703	197097	1082465	27.1	427.9
0710	196891	1082693	27.8	427.2
0713	196683	1082926	26.1	428.9
0720	196487	1083191	30.1	424.9
Survey Line #16				
0730	197829	1081517	19.8	435.2
0733	197685	1081709	22.2	432.8
0740	197557	1081965	20.0	435.0
0743	197378	1082229	21.9	433.1
0750	197136	1082478	26.3	428.7
0753	196909	1082750	27.9	427.1
Survey Line #17				
0770	197976	1080857	17.5	437.5
0773	198009	1081475	20.7	434.3
0780	197857	1081696	20.3	434.7
0783	197684	1081940	15.6	439.4

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
Survey Date/Time : 23 July 1994, 0904 to 1304 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 455.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #17 cont.				
0790	197485	1082204	16.6	438.4
0793	197258	1082456	19.2	435.8
0800	197063	1082724	19.5	435.5
0803	196871	1082984	16.5	438.5
0810	196642	1083245	13.9	441.1

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 50 E
Survey Date/Time : 23 July 1994, 1325 to 1419 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 455.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #52				
0820	196898	1080726	17.9	437.1
0823	197121	1080866	16.9	438.1
0830	197318	1081013	15.7	439.3
0833	197511	1081138	20.1	434.9
0840	197699	1081244	22.9	432.1
0843	197862	1081375	22.0	433.0
0850	197986	1081546	22.1	432.9

Survey Line #53				
0853	196626	1080974	13.0	442.0
0860	196789	1081139	17.8	437.2
0863	197029	1081281	18.4	436.6
0870	197216	1081451	22.5	432.5
0873	197465	1081605	28.1	426.9
0880	197669	1081755	20.5	434.5
0883	197839	1081949	16.2	438.8

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 50 E
 Survey Date/Time : 23 July 1994, 1325 to 1419 hours
 Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 455.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #54				
0890	196489	1081396	18.0	437.0
0893	196691	1081582	20.4	434.6
0900	196983	1081716	24.7	430.3
0903	197201	1081858	27.3	427.7
0910	197412	1082022	23.0	432.0
0913	197610	1082237	--	---
Survey Line #55				
0920	196146	1081679	16.4	438.6
0923	196356	1081796	20.5	434.5
0930	196549	1081954	22.5	432.5
0933	196790	1082101	25.2	429.8
0940	197045	1082224	28.1	426.9
0943	197214	1082381	21.1	433.9
Survey Line #56				
0950	195899	1082009	19.6	435.4
0953	196212	1082122	22.1	432.9
0960	196396	1082288	22.9	432.1
0963	196620	1082456	23.5	431.5
0970	196858	1082603	28.0	427.0
0973	196966	1082837	20.4	434.6
Survey Line #57				
0980	195908	1082467	--	---
0983	196174	1082589	--	---
0990	196388	1082705	--	---
0993	196600	1082805	--	---
1000	196682	1082974	--	---

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
Survey Date/Time : 22 July 1994, 1416 to 1735 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 459.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #27				
0000	194886	1083540	14.4	445.1
0003	194783	1083623	--	---
0010	194707	1083723	17.3	442.2
0013	194625	1083829	16.6	442.9
0020	194555	1083946	17.0	442.5
0023	194496	1084046	17.3	442.2
0030	194422	1084139	17.6	441.9
0033	194333	1084243	19.0	440.5
0040	194232	1084390	20.8	438.7
0043	194122	1084540	21.2	438.3
0050	194003	1084694	23.1	436.4
Survey Line #28				
0063	194788	1083822	--	---
0070	194678	1083937	18.3	441.2
0073	194587	1084074	18.4	441.1
0080	194502	1084180	19.0	440.5
0083	194418	1084307	19.5	440.0
0090	194327	1084416	21.5	438.0
0093	194249	1084554	21.7	437.8
0100	194147	1084658	20.2	439.3
0103	194060	1084791	19.5	440.0
Survey Line #29				
0113	195071	1083603	20.2	439.3
0120	194948	1083731	17.8	441.7
0123	194860	1083892	18.1	441.4
0130	194745	1084022	19.8	439.7
0133	194663	1084161	19.3	440.2
0140	194544	1084294	19.5	440.0
0143	194447	1084444	19.9	439.6
0150	194324	1084585	20.2	439.3
0153	194208	1084735	17.0	442.5
0160	194105	1084900	15.5	444.0

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
Survey Date/Time : 22 July 1994, 1416 to 1735 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 459.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #30				
0163	195181	1083602	23.8	435.7
0170	195114	1083737	23.9	435.6
0173	194997	1083871	20.5	439.0
0180	194876	1084011	20.4	439.1
0183	194777	1084172	20.6	438.9
0190	194661	1084301	20.2	439.3
0193	194574	1084452	21.9	437.6
0200	194462	1084586	18.9	440.6
0203	194341	1084733	17.8	441.7
0210	194234	1084889	15.6	443.9
Survey Line #31				
0220	195179	1083785	24.9	434.6
0223	195047	1083923	24.0	435.5
0230	194961	1084086	22.8	436.7
0233	194829	1084234	22.7	436.8
0240	194722	1084378	20.4	439.1
0243	194610	1084558	19.3	440.2
0250	194466	1084716	16.2	443.3
0253	194352	1084878	15.7	443.8
0260	194244	1085072	14.2	445.3
Survey Line #32				
0270	195347	1083652	25.5	434.0
0273	195280	1083795	25.2	434.3
0280	195180	1083938	25.5	434.0
0283	195079	1084081	24.7	434.8
0290	194960	1084214	22.6	436.9
0293	194852	1084356	22.0	437.5
0300	194747	1084510	19.6	439.9
0303	194650	1084680	18.6	440.9
0310	194514	1084822	15.5	444.0
0313	194394	1084974	15.8	443.7
0320	194314	1085159	14.8	444.7

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
Survey Date/Time : 22 July 1994, 1416 to 1735 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 459.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #33				
0323	195381	1083841	25.3	434.2
0330	195275	1083974	24.7	434.8
0333	195161	1084108	24.7	434.8
0340	195064	1084258	20.1	439.4
0343	194945	1084395	20.6	438.9
0350	194829	1084536	20.4	439.1
0353	194730	1084705	17.7	441.8
0360	194633	1084876	18.4	441.1
0363	194506	1085033	16.4	443.1
0370	194353	1085162	15.9	443.6
Survey Line #34				
0373	195444	1083854	25.5	434.0
0380	195368	1084015	24.6	434.9
0383	195256	1084159	25.8	433.7
0390	195135	1084289	17.7	441.8
0393	195056	1084449	17.8	441.7
0400	194959	1084599	16.9	442.6
0403	194827	1084741	18.0	441.5
0410	194704	1084891	18.6	440.9
0413	194612	1085064	18.1	441.4
0420	194502	1085233	17.6	441.9
Survey Line #35				
0423	195520	1083960	25.3	434.2
0430	195423	1084106	25.0	434.5
0433	195328	1084264	19.6	439.9
0440	195216	1084409	16.3	443.2
0443	195098	1084549	16.0	443.5
0450	194994	1084702	16.6	442.9
0453	194869	1084850	17.5	442.0
0460	194755	1085012	19.9	439.6
0463	194652	1085180	18.0	441.5
0470	194496	1085302	17.2	442.3

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
 Survey Date/Time : 22 July 1994, 1416 to 1735 hours
 Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 459.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #36				
0473	195628	1083946	25.6	433.9
0480	195552	1084103	24.4	435.1
0483	195399	1084234	19.5	440.0
0490	195321	1084402	17.7	441.8
0493	195205	1084550	15.5	444.0
0500	195080	1084694	16.0	443.5
0503	194994	1084862	17.1	442.4
0510	194865	1085023	19.5	440.0
0513	194733	1085170	16.0	443.5
0520	194643	1085344	15.5	444.0
Survey Line #37				
0523	195723	1084008	27.3	432.2
0530	195596	1084151	21.3	438.2
0533	195505	1084304	20.1	439.4
0540	195393	1084465	18.5	441.0
0543	195273	1084620	17.4	442.1
0550	195195	1084794	17.0	442.5
0553	195044	1084954	18.3	441.2
0560	194909	1085116	15.9	443.6
0563	194815	1085314	18.4	441.1
Survey Line #38				
0573	195723	1084168	23.6	435.9
0580	195656	1084327	21.3	438.2
0583	195492	1084469	19.7	439.8
0590	195421	1084655	22.2	437.3
0593	195233	1084768	17.1	442.4
0600	195171	1084946	20.6	438.9
0603	195049	1085118	16.9	442.6
0610	194935	1085294	17.5	442.0
0613	194767	1085444	17.0	442.5

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
Survey Date/Time : 22 July 1994, 1416 to 1735 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 459.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #39				
0620	195797	1084264	25.1	434.4
0623	195685	1084438	22.4	437.1
0630	195549	1084600	24.2	435.3
0633	195442	1084777	22.9	436.6
0640	195302	1084945	20.9	438.6
0643	195160	1085112	18.8	440.7
0650	195031	1085288	18.1	441.4
0653	194913	1085464	16.6	442.9
Survey Line #40				
0660	195989	1084118	33.2	426.3
0663	195879	1084300	28.8	430.7
0670	195770	1084492	23.8	435.7
0673	195645	1084666	24.3	435.2
0680	195529	1084847	23.9	435.6
0683	195378	1085001	21.9	437.6
0690	195260	1085185	18.8	440.7
0693	195140	1085356	17.3	442.2
Survey Line #41				
0703	196017	1084310	26.8	432.7
0710	195873	1084517	27.4	432.1
0713	195746	1084714	24.2	435.3
0720	195604	1084883	23.3	436.2
0723	195484	1085067	22.9	436.6
0730	195344	1085228	18.7	440.8
0733	195239	1085405	19.3	440.2
Survey Line #42				
0743	196124	1084325	24.8	434.7
0750	196002	1084532	24.8	434.7
0753	195837	1084722	23.0	436.5
0760	195715	1084924	23.9	435.6
0763	195549	1085094	22.2	437.3
0770	195429	1085276	23.1	436.4
0773	195291	1085433	20.3	439.2

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
Survey Date/Time : 22 July 1994, 1416 to 1735 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 459.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #43				
0780	196122	1084464	22.7	436.8
0783	196010	1084682	23.0	436.5
0790	195841	1084880	21.9	437.6
0793	195710	1085096	23.7	435.8
0800	195558	1085281	23.0	436.5
0803	195407	1085465	24.9	434.6

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 50 E
Survey Date/Time : 23 July 1994, 1550 to 1633 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 459.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #69				
0810	193847	1084716	23.6	435.9
0813	194051	1084887	16.2	443.3
0820	194221	1085072	14.6	444.9
0823	194497	1085191	17.4	442.1
0830	194721	1085357	17.7	441.8
0833	194914	1085516	17.1	442.4
Survey Line #68				
0840	194219	1084543	20.4	439.1
0843	194466	1084718	15.8	443.7
0850	194732	1084881	18.3	441.2
0853	195003	1085059	16.5	443.0
0860	195294	1085186	19.5	440.0
0863	195515	1085342	22.9	436.6
0870	195714	1085560	--	---
Survey Line #67				
0873	194508	1084270	20.2	439.3
0880	194767	1084431	21.3	438.2
0883	195051	1084595	15.8	443.7
0890	195291	1084763	20.8	438.7
0893	195568	1084930	22.9	436.6
0900	195786	1085133	21.0	438.5
Survey Line #66				
0910	194759	1083946	18.5	441.0
0913	195024	1084127	25.3	434.2
0920	195288	1084313	20.0	439.5
0923	195522	1084481	22.0	437.5
0930	195746	1084652	24.1	435.4
0933	195950	1084835	21.3	438.2
Survey Line #65				
0940	195085	1083662	23.5	436.0
0943	195347	1083844	25.2	434.3
0950	195615	1084009	25.6	433.9
0953	195862	1084163	31.0	428.5
0960	196117	1084286	24.8	434.7

Appendix D

Lock and Dam 22 Positioning Information for the 'Boomer' Data

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
 Survey Date/Time : 23 July 1994, 0904 to 1304 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 455.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #3				
0000	196862	1080637	--	---
0003	196706	1080841	15.7	439.3
0010	196560	1081043	13.9	441.1
0013	196405	1081233	16.6	438.4
0020	196244	1081447	15.5	439.5
0023	196045	1081698	16.3	438.7
0030	195843	1082008	18.1	436.9
Survey Line #4				
0033	196923	1080711	18.0	437.0
0040	196729	1080973	16.4	438.6
0043	196538	1081232	17.2	437.8
0050	196352	1081488	17.6	437.4
0053	196155	1081739	17.9	437.1
0060	195976	1081998	19.7	435.3
0063	195821	1082300	--	---
0070	195572	1082699	18.2	436.8
Survey Line #5				
0073	197023	1080740	17.7	437.3
0080	196800	1081036	17.1	437.9
0083	196609	1081371	18.0	437.0
0090	196348	1081680	17.0	438.0
0093	196079	1082012	20.1	434.9
0100	195853	1082483	21.9	433.1
0103	195557	1082905	19.0	436.0
Survey Line #6				
0110	196952	1080983	17.9	437.1
0113	196709	1081332	18.3	436.7
0120	196466	1081659	18.8	436.2
0123	196206	1082020	20.4	434.6
0130	195999	1082474	22.5	432.5
0133	195705	1082868	20.6	434.4

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
Survey Date/Time : 23 July 1994, 0904 to 1304 hours
Acoustic Source : 'Boomer' System operating at 500-2000 Hertz

Water Level Elevation : 455.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #7				
0140	197168	1080843	18.1	436.9
0143	196955	1081169	18.1	436.9
0150	196675	1081513	18.7	436.3
0153	196424	1081924	22.0	433.0
0160	196187	1082366	23.2	431.8
0163	195914	1082756	22.1	432.9
Survey Line #8				
0173	197152	1081176	17.8	437.2
0180	196866	1081502	20.5	434.5
0183	196598	1081879	22.7	432.3
0190	196374	1082230	22.6	432.4
0193	196136	1082627	23.9	431.1
Survey Line #9				
0203	197208	1081141	18.1	436.9
0210	196988	1081465	23.0	432.0
0213	196783	1081880	24.0	431.0
0220	196490	1082177	23.3	431.7
0223	196253	1082677	23.6	431.4
Survey Line #10				
0233	197335	1081210	17.3	437.7
0240	197038	1081511	23.8	431.2
0243	196886	1081890	23.9	431.1
0250	196719	1082163	24.2	430.8
0253	196406	1082529	23.6	431.4
0260	196022	1083002	25.1	429.9
Survey Line #11				
0263	197507	1081142	18.7	436.3
0270	197244	1081458	21.9	433.1
0273	196993	1081877	25.7	429.3
0280	196678	1082319	23.8	431.2
0283	196401	1082698	24.6	430.4
0290	196141	1083070	26.3	428.7

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
 Survey Date/Time : 23 July 1994, 0904 to 1304 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 455.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #12				
0293	197584	1081164	21.0	434.0
0300	197367	1081544	24.5	430.5
0303	197016	1081962	26.1	428.9
0310	196728	1082359	24.0	431.0
0313	196478	1082823	25.4	429.6
Survey Line #13				
0323	197652	1081273	19.7	435.3
0330	197292	1081689	25.3	429.7
0333	197037	1082149	25.8	429.2
0340	196790	1082469	25.1	429.9
0343	196535	1082895	26.0	429.0
0350	196370	1083163	28.8	426.2
Survey Line #14				
0360	197507	1081545	25.7	429.3
0363	197293	1081974	25.9	429.1
0370	197014	1082369	25.1	429.9
0373	196814	1082668	27.1	427.9
0380	196655	1082900	26.5	428.5
0383	196380	1083240	29.4	425.6
Survey Line #15				
0390	197844	1081320	21.0	434.0
0393	197616	1081642	24.3	430.7
0400	197378	1082078	25.8	429.2
0403	197080	1082485	27.1	427.9
0410	196739	1082871	25.8	429.2
0413	196413	1083296	30.1	424.9
Survey Line #16				
0420	197871	1081443	17.8	437.2
0423	197645	1081795	20.6	434.4
0430	197386	1082216	22.0	433.0
0433	196990	1082660	28.2	426.8
0440	196641	1083131	29.2	425.8

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
Survey Date/Time : 23 July 1994, 0904 to 1304 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 455.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #17				
0450	197813	1081763	17.2	437.8
0453	197455	1082244	15.6	439.4
0460	197063	1082724	19.9	435.1
0463	196667	1083208	13.6	441.4

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 50 E
 Survey Date/Time : 23 July 1994, 1325 to 1419 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 455.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #52				
0473	197171	1080915	17.7	437.3
0480	197561	1081158	21.3	433.7
0483	197868	1081382	21.6	433.4
Survey Line #53				
0493	196981	1081244	18.1	436.9
0500	197363	1081552	25.9	429.1
0503	197715	1081846	15.1	439.9
Survey Line #54				
0510	196530	1081430	17.5	437.5
0513	196998	1081720	24.6	430.4
0520	197392	1082005	25.1	429.9
Survey Line #55				
0530	196482	1081886	21.7	433.3
0533	196932	1082150	26.3	428.7
0540	197303	1082444	16.1	438.9
Survey Line #56				
0543	196246	1082142	21.9	433.1
0550	196609	1082449	24.2	430.8
0553	196959	1082790	22.0	433.0
Survey Line #57				
0560	196064	1082542	6.5	448.5
0563	196490	1082738	5.4	449.6
0570	196702	1083025	6.4	448.6

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
Survey Date/Time : 22 July 1994, 1416 to 1735 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 459.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #27				
0000	194883	1083543	--	---
0003	194724	1083699	17.0	442.5
0010	194587	1083894	17.6	441.9
0013	194473	1084076	14.8	444.7
0020	194323	1084254	19.0	440.5
0023	194141	1084512	21.5	438.0
0030	193934	1084796	23.5	436.0
Survey Line #28				
0033	194862	1083687	--	---
0040	194678	1083937	18.2	441.3
0043	194511	1084166	19.4	440.1
0050	194360	1084366	20.8	438.7
0053	194215	1084583	21.1	438.4
0060	194060	1084791	19.6	439.9
Survey Line #29				
0063	195090	1083576	20.2	439.3
0070	194906	1083816	19.6	439.9
0073	194744	1084066	19.7	439.8
0080	194544	1084294	19.6	439.9
0083	194365	1084537	19.8	439.7
0090	194172	1084777	16.5	443.0
Survey Line #30				
0100	195016	1083845	20.7	438.8
0103	194834	1084084	21.3	438.2
0110	194650	1084321	20.0	439.5
0113	194472	1084564	18.8	440.7
0120	194289	1084819	14.6	444.9
Survey Line #31				
0130	195053	1083917	24.5	435.0
0133	194872	1084174	21.8	437.7
0140	194688	1084439	20.3	439.2
0143	194472	1084712	16.1	443.4
0150	194280	1084995	14.0	445.5

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
 Survey Date/Time : 22 July 1994, 1416 to 1735 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 459.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #32				
0160	195142	1083982	24.5	435.0
0163	194941	1084240	22.2	437.3
0170	194743	1084518	19.5	440.0
0173	194529	1084809	16.1	443.4
Survey Line #33				
0183	195286	1083964	24.7	434.8
0190	195087	1084221	20.6	438.9
0193	194873	1084484	20.0	439.5
0200	194679	1084782	17.5	442.0
0203	194453	1085075	16.5	443.0
Survey Line #34				
0210	195435	1083872	25.3	434.2
0213	195256	1084159	25.8	433.7
0220	195066	1084427	18.2	441.3
0223	194865	1084702	17.8	441.7
0230	194650	1084989	19.8	439.7
Survey Line #35				
0240	195411	1084128	25.4	434.1
0243	195216	1084409	16.3	443.2
0250	195007	1084690	16.8	442.7
0253	194776	1084971	19.6	439.9
0260	194554	1085253	17.2	442.3
Survey Line #36				
0263	195588	1084037	25.4	434.1
0270	195359	1084292	20.8	438.7
0273	195156	1084605	16.0	443.5
0280	194966	1084898	17.4	442.1
0283	194727	1085177	16.1	443.4
Survey Line #37				
0293	195522	1084272	20.9	438.6
0300	195306	1084569	16.9	442.6

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
 Survey Date/Time : 22 July 1994, 1416 to 1735 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 459.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line # 37 cont.				
0303	195108	1084885	18.0	441.5
0310	194863	1085201	18.5	441.0
Survey Line #38				
0313	194690	1085509	16.7	442.8
0320	195649	1084334	21.5	438.0
0323	195434	1084619	21.2	438.3
0330	195164	1084858	18.3	441.2
0333	194974	1085183	17.1	442.4
0340	194756	1085463	16.3	443.2
Survey Line #39				
0343	195727	1084384	23.9	435.6
0350	195531	1084667	23.7	435.8
0353	195302	1084945	20.9	438.6
0360	195080	1085233	17.9	441.6
0363	194793	1085470	16.5	443.0
Survey Line #40				
0370	195879	1084309	28.6	430.9
0373	195677	1084623	24.3	435.2
0380	195461	1084917	23.0	436.5
0383	195241	1085225	19.4	440.1
0390	195004	1085498	18.2	441.3
Survey Line #41				
0393	195939	1084437	27.4	432.1
0400	195719	1084785	24.5	435.0
0403	195480	1085075	23.8	435.7
0410	195262	1085367	13.7	445.8
Survey Line #42				
0420	195902	1084635	24.9	434.6
0423	195664	1084976	25.4	434.1
0430	195424	1085283	23.5	436.0

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 40 W (Upstream)
Survey Date/Time : 22 July 1994, 1416 to 1735 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 459.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #43				
0433	196149	1084410	24.1	435.4
0440	195917	1084777	26.1	433.4
0443	195661	1085137	20.9	438.6
0450	195414	1085458	25.9	433.6

**Lock and Dam 22
Upper Mississippi River**

Survey Direction : N 50 E
 Survey Date/Time : 22 July 1994, 1550 to 1633 hours
 Acoustic Source : 'Boomer' System operating at 500-2000 Hertz

Water Level Elevation : 459.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #65				
0533	195397	1083884	25.4	434.1
0540	195834	1084143	30.3	429.2
0543	196269	1084361	15.3	444.2
Survey Line #66				
0513	194842	1083985	20.5	439.0
0520	195266	1084297	19.8	439.7
0523	195657	1084585	24.4	435.1
0530	196019	1084902	20.6	438.9
Survey Line #67				
0493	194521	1084277	21.0	438.5
0500	195008	1084563	16.2	443.3
0503	195443	1084853	23.1	436.4
0510	195834	1085179	19.7	439.8
Survey Line #68				
0473	194283	1084562	20.0	439.5
0480	194717	1084877	18.1	441.4
0483	195197	1085151	19.1	440.4
0490	195618	1085443	18.0	441.5
Survey Line #69				
0460	194005	1084824	18.5	441.0
0463	194363	1085142	16.9	442.6
0470	194790	1085409	18.0	441.5

Appendix E

Lock and Dam 24 Positioning

Information for the 'Pinger'

Data

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
Survey Date/Time : 21 July 1994, 0934 to 1241 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #1				
0933	387095	1287358	15.6	425.4
0940	386932	1287534	14.2	426.8
0943	386751	1287719	11.4	429.6
0950	386599	1287905	14.7	426.3
0953	386431	1288068	11.7	429.3
0960	386268	1288252	11.2	429.8
Survey Line #2				
0963	387408	1287419	16.5	424.5
0970	387236	1287537	18.4	422.6
0973	387111	1287643	16.2	424.8
0980	387001	1287732	18.2	422.8
0983	386896	1287816	16.9	424.1
0990	386782	1287918	19.1	421.9
0993	386666	1288013	18.4	422.6
1000	386561	1288094	13.8	427.2
1003	386488	1288176	16.2	424.8
1010	386400	1288238	12.9	428.1
1013	386314	1288306	12.7	428.3
1020	386217	1288379	12.0	429.0
1023	386107	1288466	13.1	427.9
Survey Line #3				
1033	387470	1287463	17.2	423.8
1040	387389	1287535	21.1	419.9
1043	387294	1287617	18.2	422.8
1050	387213	1287683	19.9	421.1
1053	387131	1287755	20.6	420.4
1060	387036	1287824	18.3	422.7
1063	386955	1287895	20.7	420.3
1070	386869	1287970	18.4	422.6
1073	386787	1288033	20.7	420.3
1080	386697	1288099	17.7	423.3
1083	386619	1288169	17.3	423.7
1090	386523	1288242	17.1	423.9

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
 Survey Date/Time : 21 July 1994, 0934 to 1241 hours
 Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #3 cont.				
1093	386437	1288318	15.9	425.1
1100	386351	1288388	16.9	424.1
1103	386269	1288461	17.5	423.5
1110	386188	1288531	16.4	424.6
1113	386086	1288603	17.9	423.1
Survey Line #4				
1120	387606	1287468	20.9	420.1
1123	387450	1287620	20.9	420.1
1130	387273	1287780	20.2	420.8
1133	387086	1287929	20.2	420.8
1140	386902	1288081	19.6	421.4
1143	386708	1288234	20.3	420.7
1150	386519	1288385	17.8	423.2
1153	386343	1288526	18.1	422.9
1160	386171	1288671	20.1	420.9
1163	385999	1288805	24.0	417.0
1170	385816	1288946	20.2	420.8

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
 Survey Date/Time : 20 July 1994, 1420 to 1617 hours
 Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #5				
0000	387497	1287704	--	---
0003	387347	1287839	22.7	418.3
0010	387175	1287976	23.2	417.8
0013	387007	1288118	22.7	418.3
0020	386831	1288262	22.4	418.6
0023	386653	1288413	20.1	420.9
0030	386462	1288556	21.0	420.0
0033	386281	1288725	20.5	420.5
0040	386060	1288881	20.4	420.6
0043	385836	1289095	20.4	420.6
0050	385535	1289314	10.9	430.1
0053	385629	1289467	41.7	399.3
Survey Line #6				
0063	387950	1287558	23.8	417.2
0070	387827	1287587	22.9	418.1
0073	387670	1287689	22.3	418.7
0080	387522	1287828	22.4	418.6
0083	387363	1287949	21.5	419.5
0090	387214	1288081	20.6	420.4
0093	387070	1288206	21.8	419.2
0100	386905	1288338	22.0	419.0
0103	386722	1288473	19.7	421.3
0110	386565	1288616	20.3	420.7
0113	386383	1288753	19.1	421.9
0120	386206	1288900	18.8	422.2
0123	386022	1289051	21.3	419.7
0130	385800	1289263	28.0	413.0
0133	385527	1289444	29.7	411.3
Survey Line #7				
0143	387876	1287521	23.9	417.1
0150	387810	1287716	22.6	418.4
0153	387655	1287846	21.3	419.7
0160	387503	1287977	18.4	422.6

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
 Survey Date/Time : 20 July 1994, 1420 to 1617 hours
 Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line # 7 cont.				
0163	387342	1288103	21.8	419.2
0170	387178	1288233	20.0	421.0
0173	387017	1288359	24.4	416.6
0180	386852	1288493	24.2	416.8
0183	386686	1288642	20.4	420.6
0190	386514	1288785	21.9	419.1
0193	386338	1288922	19.7	421.3
0200	386168	1289075	22.2	418.8
0203	385992	1289240	28.6	412.4
0210	385749	1289415	41.5	399.5
0213	385477	1289659	--	---
Survey Line #8				
0220	387826	1287841	22.4	418.6
0223	387669	1287958	22.2	418.8
0230	387518	1288088	20.4	420.6
0233	387289	1288270	23.1	417.9
0240	387114	1288412	26.5	414.5
0243	386936	1288570	31.1	409.9
0250	386743	1288716	24.7	416.3
0253	386577	1288861	24.4	416.6
0260	386382	1289024	24.1	416.9
0263	386169	1289195	24.5	416.5
0270	385941	1289411	34.8	406.2
0273	385597	1289639	35.6	405.4
Survey Line #9				
0280	387940	1287743	23.7	417.3
0283	387878	1287934	24.2	416.8
0290	387721	1288050	22.9	418.1
0293	387573	1288173	21.0	420.0
0300	387429	1288283	23.0	418.0
0303	387306	1288399	23.5	417.5
0310	387143	1288526	29.0	412.0
0313	386965	1288665	30.1	410.9

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
 Survey Date/Time : 20 July 1994, 1420 to 1617 hours
 Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line # 9 cont.				
0320	386782	1288817	28.5	412.5
0323	386595	1288960	28.0	413.0
0330	386432	1289108	27.7	413.3
0333	386255	1289251	27.3	413.7
0340	386015	1289462	30.7	410.3
0343	385684	1289685	41.8	399.2
Survey Line #10				
0350	387983	1287842	23.0	418.0
0353	387876	1288051	25.4	415.6
0360	387685	1288204	25.0	416.0
0363	387520	1288340	22.4	418.6
0370	387374	1288471	21.9	419.1
0373	387212	1288590	24.4	416.6
0380	387070	1288700	29.0	412.0
0383	386911	1288839	30.9	410.1
0390	386729	1288994	31.2	409.8
0393	386518	1289161	31.5	409.5
0400	386299	1289332	28.6	412.4
0403	386093	1289530	31.8	409.2
0410	385787	1289733	46.3	394.7
Survey Line #11				
0413	387931	1288135	23.6	417.4
0420	387701	1288317	21.7	419.3
0423	387503	1288480	23.1	417.9
0430	387314	1288619	20.8	420.2
0433	387176	1288747	22.7	418.3
0440	387007	1288885	30.8	410.2
0443	386835	1289011	30.8	410.2
0450	386663	1289154	30.8	410.2
0453	386461	1289335	30.5	410.5
0460	386246	1289513	30.9	410.1
0463	386031	1289702	37.0	404.0

Lock and Dam 24
Upper Mississippi River

Survey Direction : N 50 W (Upstream)
Survey Date/Time : 20 July 1994, 1420 to 1617 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #12				
0473	388040	1288058	20.5	420.5
0480	387918	1288263	19.6	421.4
0483	387712	1288449	19.4	421.6
0490	387486	1288622	19.0	422.0
0493	387336	1288741	14.6	426.4
0500	387231	1288837	12.7	428.3
0503	387097	1288946	13.1	427.9
0510	386934	1289075	19.0	422.0
0513	386788	1289184	29.6	411.4
0520	386678	1289305	32.8	408.2
0523	386498	1289435	31.0	410.0
0530	386304	1289597	29.5	411.5
0533	386044	1289794	41.2	399.8

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
Survey Date/Time : 21 July 1994, 0934 to 1241 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #15				
0810	387139	1289045	13.8	427.2
0813	386930	1289204	24.0	417.0
0820	386657	1289422	29.1	411.9
0823	386395	1289640	26.9	414.1
0830	386114	1289852	39.3	401.7
Survey Line #16				
0840	387006	1289359	--	---
0843	386716	1289492	31.6	409.4
0850	386460	1289716	26.4	414.6
0853	386196	1289926	35.4	405.6
Survey Line #17				
0873	386390	1289873	30.1	410.9
0880	386164	1290090	39.0	402.0
Survey Line #18				
0890	386472	1289940	32.2	408.8
0893	386253	1290116	40.4	400.6
Survey Line #19				
0913	386766	1290094	30.9	410.1
0920	386441	1290259	57.1	383.9
0923	386207	1290456	26.7	414.3
Survey Line #20				
0903	386554	1290045	48.9	392.1
0910	386262	1290275	43.4	397.6

Survey Line #21

No Positioning or Depth Information Available

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 40 E
Survey Date/Time : 20 July 1994, 1658 to 1804 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #56				
0610	388077	1288607	23.3	417.7
0613	387880	1288313	18.2	422.8
0620	387680	1288022	19.7	421.3
0623	387461	1287779	20.1	420.9
0630	387240	1287541	15.8	425.2
Survey Line #57				
0570	387206	1287655	20.9	420.1
0573	387263	1287813	22.7	418.3
0580	387382	1287965	21.4	419.6
0583	387504	1288108	20.5	420.5
0590	387584	1288254	23.0	418.0
0593	387738	1288394	21.2	419.8
0600	387799	1288612	19.8	421.2
0603	388039	1288728	--	---
Survey Line #58				
0640	386829	1287820	16.5	424.5
0643	386919	1288037	19.9	421.1
0650	387109	1288244	18.1	422.9
0653	387302	1288445	19.4	421.6
0660	387435	1288668	15.8	425.2
0663	387619	1288922	13.4	427.6
0670	387838	1289124	16.1	424.9
Survey Line #59				
0673	386552	1287941	13.9	427.1
0680	386721	1288157	19.8	421.2
0683	386914	1288380	24.0	417.0
0690	387117	1288588	24.8	416.2
0693	387293	1288824	11.9	429.1
Survey Line #60				
0700	386301	1288273	12.9	428.1
0703	386507	1288486	17.3	423.7
0710	386689	1288714	21.7	419.3
0713	386869	1288928	28.0	413.0
0720	387055	1289150	17.8	423.2

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 40 E
 Survey Date/Time : 20 July 1994, 1658 to 1804 hours
 Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #61				
0723	386147	1288675	18.2	422.8
0730	386336	1288908	19.4	421.6
0733	386531	1289144	27.5	413.5
0740	386687	1289377	30.6	410.4
Survey Line #62				
0750	385938	1289053	19.8	421.2
0753	386111	1289294	24.5	416.5
0760	386369	1289500	25.0	416.0
0763	386489	1289770	29.2	411.8
0770	386710	1290046	29.6	411.4
Survey Line #63				
0780	385682	1289379	35.3	405.7
0783	385871	1289603	35.9	405.1
0790	386092	1289854	37.7	403.3
0793	386313	1290115	39.3	401.7
0800	386491	1290404	--	---

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
Survey Date/Time : 21 July 1994, 1312 to 1610 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 447.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #26				
0000	384791	1289750	20.1	427.4
0003	384617	1289898	21.6	425.9
0010	384443	1290015	20.3	427.2
0013	384290	1290119	18.7	428.8
0020	384161	1290229	19.3	428.2
0023	384030	1290335	19.7	427.8
0030	383884	1290446	19.6	427.9
0033	383734	1290562	16.8	430.7
0040	383590	1290683	17.0	430.5
0043	383446	1290794	21.4	426.1
Survey Line #27				
0050	384837	1289816	19.8	427.7
0053	384684	1289970	16.7	430.8
0060	384523	1290093	17.9	429.6
0063	384353	1290212	18.4	429.1
0070	384186	1290339	19.9	427.6
0073	384020	1290476	19.6	427.9
0080	383846	1290604	21.3	426.2
0083	383691	1290741	23.2	424.3
0090	383539	1290870	22.2	425.3
Survey Line #28				
0093	384732	1290092	17.4	430.1
0100	384539	1290186	17.9	429.6
0103	384397	1290336	17.0	430.5
0110	384227	1290444	19.5	428.0
0113	384068	1290569	19.8	427.7
0120	383902	1290694	21.9	425.6
0123	383739	1290831	24.4	423.1
0130	383587	1290958	23.4	424.1
Survey Line #29				
0133	385141	1289873	24.3	423.2
0140	384956	1290026	28.9	418.6
0143	384769	1290164	19.7	427.8
0150	384599	1290287	16.2	431.3

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
 Survey Date/Time : 21 July 1994, 1312 to 1610 hours
 Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 447.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #29 cont.				
0153	384421	1290418	18.7	428.8
0160	384249	1290557	19.6	427.9
0163	384097	1290694	20.4	427.1
0170	383916	1290806	22.7	424.8
0173	383759	1290955	24.9	422.6
0180	383596	1291075	21.2	426.3
Survey Line #30				
0183	385213	1289969	39.0	408.5
0190	385043	1290053	32.0	415.5
0193	384884	1290180	27.1	420.4
0200	384722	1290310	25.8	421.7
0203	384561	1290429	22.4	425.1
0210	384407	1290559	21.8	425.7
0213	384241	1290692	22.1	425.4
0220	384076	1290822	21.2	426.3
0223	383908	1290953	22.6	424.9
0230	383734	1291091	19.2	428.3
Survey Line #31				
0233	385350	1289886	34.8	412.7
0240	385269	1290041	34.2	413.3
0243	385084	1290157	31.2	416.3
0250	384929	1290233	27.2	420.3
0253	384792	1290386	26.7	420.8
0260	384622	1290505	24.8	422.7
0263	384459	1290638	21.9	425.6
0270	384295	1290772	22.1	425.4
0273	384128	1290907	21.6	425.9
0280	383952	1291036	21.3	426.2
0283	383784	1291177	19.7	427.8
Survey Line #32				
0290	385332	1290050	31.6	415.9
0293	385196	1290188	30.0	417.5
0300	385027	1290312	29.5	418.0
0303	384865	1290444	27.4	420.1
0310	384706	1290581	24.8	422.7

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
Survey Date/Time : 21 July 1994, 1312 to 1610 hours
Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 447.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #32 cont.				
0313	384541	1290711	24.8	422.7
0320	384378	1290845	21.6	425.9
0323	384201	1290964	22.1	425.4
0330	384038	1291109	18.6	428.9
0333	383871	1291249	20.5	427.0
Survey Line #33				
0340	385513	1290088	33.4	414.1
0343	385349	1290171	30.5	417.0
0350	385188	1290297	28.9	418.6
0353	385031	1290432	29.2	418.3
0360	384862	1290561	26.6	420.9
0363	384703	1290702	25.4	422.1
0370	384533	1290832	26.9	420.6
0373	384361	1290958	22.4	425.1
0380	384195	1291096	19.1	428.4
0383	384036	1291233	19.7	427.8
0390	383862	1291364	19.9	427.6
Survey Line #34				
0393	385419	1290250	30.3	417.2
0400	385290	1290409	30.6	416.9
0403	385127	1290522	29.8	417.7
0410	384961	1290634	28.1	419.4
0413	384819	1290765	25.2	422.3
0420	384645	1290876	26.5	421.0
0423	384499	1291021	22.9	424.6
0430	384319	1291129	20.4	427.1
0433	384162	1291259	21.5	426.0
0440	383992	1291380	20.4	427.1
Survey Line #35				
0443	385643	1290272	34.2	413.3
0450	385443	1290364	31.6	415.9
0453	385282	1290501	30.7	416.8
0460	385112	1290632	30.4	417.1

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
 Survey Date/Time : 21 July 1994, 1312 to 1610 hours
 Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 447.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #35 cont.				
0463	384942	1290765	24.1	423.4
0470	384790	1290902	25.9	421.6
0473	384614	1291022	24.8	422.7
0480	384452	1291164	21.7	425.8
0483	384274	1291283	23.0	424.5
0490	384122	1291431	23.7	423.8
Survey Line #36				
0503	385631	1290380	35.1	412.4
0510	385435	1290482	33.9	413.6
0513	385283	1290642	28.4	419.1
0520	385098	1290766	28.3	419.2
0523	384930	1290909	26.9	420.6
0530	384758	1291049	24.2	423.3
0533	384582	1291189	23.4	424.1
0540	384399	1291320	24.7	422.8
0553	384309	1291397	25.2	422.3
0560	384133	1291542	24.2	423.3
Survey Line #37				
0570	385605	1290487	35.2	412.3
0573	385442	1290625	31.4	416.1
0580	385279	1290762	28.1	419.4
0583	385107	1290895	28.2	419.3
0590	384941	1291040	27.0	420.5
0593	384756	1291159	26.1	421.4
0600	384593	1291319	24.9	422.6
0603	384395	1291438	23.0	424.5
0610	384228	1291600	27.2	420.3
Survey Line #38				
0620	385657	1290548	31.3	416.2
0623	385520	1290701	31.1	416.4
0630	385350	1290823	29.1	418.4
0633	385185	1290966	28.2	419.3
0640	385013	1291098	23.4	424.1

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
 Survey Date/Time : 21 July 1994, 1312 to 1610 hours
 Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 447.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line # 38 cont.				
0643	384822	1291231	23.9	423.6
0650	384667	1291386	24.2	423.3
0653	384484	1291513	25.8	421.7
0660	384314	1291658	28.1	419.4
Survey Line #39				
0670	385714	1290668	28.9	418.6
0673	385548	1290790	31.9	415.6
0680	385396	1290938	29.2	418.3
0683	385217	1291043	26.9	420.6
0690	385071	1291185	26.6	420.9
0693	384897	1291300	24.8	422.7
0700	384741	1291444	25.3	422.2
0703	384569	1291582	26.2	421.3
0710	384390	1291720	28.6	418.9
0713	384201	1291849	28.2	419.3
Survey Line #40				
0720	385751	1290717	29.5	418.0
0723	385607	1290878	30.1	417.4
0730	385427	1291021	29.8	417.7
0733	385250	1291166	28.1	419.4
0740	385063	1291303	27.1	420.4
0743	384889	1291450	26.2	421.3
0750	384709	1291592	26.4	421.1
0753	384526	1291734	27.0	420.5
0760	384350	1291879	24.2	423.3
Survey Line #41				
0763	385964	1290744	33.4	414.1
0770	385771	1290906	30.7	416.8
0773	385545	1291036	28.9	418.6
0780	385352	1291212	29.5	418.0
0783	385154	1291363	26.4	421.1
0790	384965	1291526	25.7	421.8
0793	384765	1291663	24.3	423.2
0800	384583	1291821	23.8	423.7
0803	384394	1291982	21.9	425.6

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 40 E
 Survey Date/Time : 21 July 1994, 1628 to 1720 hours
 Acoustic Source : 'Pinger' System operating at 3.5 kHz

Water Level Elevation : 447.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #76				
0820	383331	1290729	19.5	428.0
0823	383515	1290928	23.4	424.1
0830	383737	1291223	19.9	427.6
0833	383986	1291494	25.8	421.7
0840	384192	1291785	27.7	419.8
0843	384437	1292073	16.7	430.8
Survey Line #75				
0850	383753	1290619	19.0	428.5
0853	383953	1290872	21.8	425.7
0860	384165	1291120	19.4	428.1
0863	384354	1291359	24.5	423.0
0870	384551	1291602	25.4	422.1
0873	384749	1291847	19.1	428.4
Survey Line #73				
0920	384171	1290506	18.8	428.7
0923	384377	1290766	23.8	423.7
0930	384570	1291003	25.2	422.3
0933	384768	1291253	24.6	422.9
0940	384972	1291493	24.5	423.0
0943	385164	1291732	--	---
Survey Line #72				
0880	384223	1290447	18.4	429.1
0883	384022	1290347	19.4	428.1
0890	383785	1290386	17.1	430.4
0893	383524	1290446	--	---
0900	383218	1290532	--	---
Survey Line #70				
0950	384938	1290246	28.5	419.0
0953	385200	1290488	30.8	416.7
0960	385384	1290740	31.7	415.8
0963	385586	1290984	26.4	421.1
0970	385760	1291234	--	---

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 75 W

Survey Date/Time : 21 July 1994, 1645 hours

Water Level Elevation : 447.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #69				
0973	385060	1290113	31.0	416.5
0980	385300	1290310	30.4	417.1
0983	385487	1290536	31.7	415.8
0990	385691	1290760	29.6	417.9
0993	385843	1290994	--	---

Appendix F

Lock and Dam 24 Positioning Information for the 'Boomer' Data

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
Survey Date/Time : 21 July 1994, 0934 to 1241 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #1				
0563	386938	1287526	14.4	426.6
0570	386678	1287798	12.8	428.2
0573	386431	1288068	12.0	429.0
Survey Line #2				
0583	387197	1287569	19.8	421.2
0590	387016	1287716	17.3	423.7
0593	386862	1287856	18.0	423.0
0600	386675	1288006	20.1	420.9
0603	386533	1288128	14.0	427.0
0610	386406	1288232	13.3	427.7
0613	386275	1288338	12.3	428.7
0620	386116	1288457	12.8	428.2
Survey Line #3				
0623	387500	1287415	21.3	419.7
0630	387387	1287536	21.3	419.7
0633	387251	1287655	19.6	421.4
0640	387120	1287760	20.1	420.9
0643	386983	1287873	19.5	421.5
0650	386856	1287982	18.4	422.6
0653	386725	1288077	17.1	423.9
0660	386600	1288186	18.1	422.9
0663	386463	1288300	17.0	424.0
0670	386338	1288399	17.8	423.2
0673	386218	1288501	16.3	424.7
0680	386082	1288608	18.4	422.6
Survey Line #4				
0683	387499	1287584	21.1	419.9
0690	387243	1287798	20.1	420.9
0693	386962	1288027	20.2	420.8
0700	386682	1288248	21.2	419.8
0703	386424	1288459	18.3	422.7
0710	386171	1288671	20.2	420.8
0713	385922	1288865	20.0	421.0

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
 Survey Date/Time : 20 July 1994, 1420 to 1617 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #5				
0000	387495	1287708	--	---
0003	387171	1287980	23.1	417.9
0010	386818	1288272	22.1	418.9
0013	386462	1288556	20.8	420.2
0020	386032	1288912	18.4	422.6
0023	385477	1289362	10.3	430.7
Survey Line #6				
0030	387788	1287605	22.6	418.4
0033	387442	1287887	22.2	418.8
0040	387120	1288162	22.4	418.6
0043	386757	1288448	18.3	422.7
0050	386400	1288739	20.5	420.5
0053	386039	1289033	21.2	419.8
0060	385564	1289414	28.0	413.0
Survey Line #7				
0070	387604	1287888	21.7	419.3
0073	387327	1288114	21.7	419.3
0080	387047	1288334	24.0	417.0
0083	386761	1288574	21.4	419.6
0090	386456	1288827	24.3	416.7
0093	386158	1289082	22.9	418.1
0100	385814	1289359	37.0	404.0
Survey Line #8				
0110	387635	1287985	21.8	419.2
0113	387364	1288202	19.4	421.6
0120	387074	1288447	28.3	412.7
0123	386753	1288710	24.9	416.1
0130	386450	1288963	25.4	415.6
0133	386081	1289249	27.0	414.0
0140	385589	1289646	36.5	404.5
Survey Line #9				
0143	387884	1287927	23.9	417.1
0150	387622	1288131	22.3	418.7

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
 Survey Date/Time : 20 July 1994, 1420 to 1617 hours
 Acoustic Source : 'Boomer' System operating at 500-2000 Hertz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #9 cont.				
0153	387379	1288327	21.4	419.6
0160	387130	1288536	29.5	411.5
0163	386827	1288778	30.2	410.8
0170	386526	1289026	28.6	412.4
0173	386232	1289270	27.3	413.7
0180	385761	1289620	44.8	396.2
Survey Line #10				
0183	387889	1288042	24.8	416.2
0190	387593	1288278	22.9	418.1
0193	387352	1288484	21.0	420.0
0200	387107	1288672	27.0	414.0
0203	386843	1288882	28.4	412.6
0210	386527	1289154	31.2	409.8
0213	386176	1289438	31.1	409.9
0220	385729	1289766	42.6	398.4
Survey Line #11				
0223	387830	1288216	26.6	414.4
0230	387488	1288490	22.9	418.1
0233	387226	1288711	21.1	419.9
0240	386948	1288919	30.3	410.7
0243	386678	1289140	31.1	409.9
0250	386340	1289416	29.0	412.0
0253	385988	1289742	37.8	403.2
Survey Line #12				
0263	387865	1288302	19.4	421.6
0270	387508	1288605	15.7	425.3
0273	387284	1288797	13.1	427.9
0280	387070	1288974	15.7	425.3
0283	386822	1289172	24.3	416.7
0290	386592	1289356	32.8	408.2
0293	386289	1289612	30.0	411.0
0300	385812	1289950	33.3	407.7

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
 Survey Date/Time : 21 July 1994, 0934 to 1241 hours
 Acoustic Source : 'Boomer' System operating at 500-2000
 Hertz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #15				
0480	387137	1289084	10.7	430.3
0483	386758	1289353	29.6	411.4
0490	386352	1289675	28.4	412.6
0493	385925	1290046	35.7	405.3
Survey Line #16				
0500	386998	1289369	--	---
0503	386574	1289608	32.9	408.1
0510	386187	1289934	36.1	404.9
Survey Line #17				
0523	386136	1290109	38.4	402.6
Survey Line #18				
0530	38664	1289911	32.9	408.1
0533	386231	1290130	40.4	400.6
Survey Line #19				
0550	386417	1290273	56.9	384.1
Survey Line #20				
0543	386140	1290409	24.8	416.2
Survey Line #21				
No Positioning or Depth Information Available				

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 40 E
 Survey Date/Time : 20 July 1994, 1658 to 1804 hours
 Acoustic Source : 'Boomer' System operating at 500-2000 Hertz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #56				
0350	387947	1288366	18.5	422.5
0353	387615	1287955	19.0	422.0
0360	387277	1287584	16.9	424.1
Survey Line #57				
0323	387278	1287824	23.2	417.8
0330	387439	1288048	20.9	420.1
0333	387599	1288276	25.3	415.7
0340	387792	1288546	19.7	421.3
0343	388072	1288781	--	---
Survey Line #58				
0370	386975	1288091	20.0	421.0
0373	387242	1288395	21.1	419.9
0380	387487	1288721	15.1	425.9
0383	387812	1289067	17.7	423.3
Survey Line #59				
0390	386656	1288108	18.6	422.4
0393	386974	1288441	26.2	414.8
0400	387258	1288783	12.3	428.7
Survey Line #60				
0403	386426	1288371	17.3	423.7
0410	386697	1288724	22.6	418.4
0413	386971	1289061	17.1	423.9
Survey Line #61				
0420	386240	1288793	17.7	423.3
0423	386531	1289144	27.5	413.5
0430	386824	1289495	12.8	428.2

Lock and Dam 24
Upper Mississippi River

Survey Direction : N 40 E
Survey Date/Time : 20 July 1994, 1658 to 1804 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 441.0 ft MSL (Below the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #62				
0433	385948	1289060	20.1	420.9
0440	386237	1289418	26.5	414.5
0443	386521	1289814	31.9	409.1
0450	386907	1290234	9.1	431.9
Survey Line #63				
0453	385738	1289401	36.5	404.5
0460	386021	1289797	37.9	403.1
0463	386348	1290200	53.2	387.8

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 50 W (Upstream)
 Survey Date/Time : 21 July 1994, 1312 to 1610 hours
 Acoustic Source : 'Boomer' System operating at 500-2000 Hertz

Water Level Elevation : 447.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #26				
0000	384727	1289820	19.6	427.9
0003	384398	1290045	18.5	429.0
0010	384133	1290252	18.9	428.6
0013	383876	1290453	19.7	427.8
0020	383605	1290672	16.9	430.6
Survey Line #27				
0030	384575	1290047	17.9	429.6
0033	384267	1290277	19.5	428.0
0040	383956	1290528	18.7	428.8
0043	383646	1290782	20.8	426.7
Survey Line #28				
0050	384706	1290107	18.3	429.2
0053	384397	1290336	16.8	430.7
0060	384092	1290549	19.9	427.6
0063	383791	1290785	22.5	425.0
0070	383555	1291034	21.7	425.8
Survey Line #29				
0073	384956	1290026	28.9	418.6
0080	384630	1290259	16.0	431.5
0083	384301	1290506	19.9	427.6
0090	384002	1290750	21.6	425.9
0093	383690	1291000	21.8	425.7
Survey Line #30				
0100	385217	1289959	38.5	409.0
0103	384918	1290162	27.4	420.1
0110	384615	1290390	22.4	425.1
0113	384323	1290629	22.4	425.1
0120	384015	1290873	21.5	426.0
0123	383691	1291123	20.7	426.8
Survey Line #31				
0130	385187	1290069	33.8	413.7
0133	384891	1290276	27.5	420.0

**Lock and Dam 24
Upper Mississippi River**

Survey Direction: N 50 W (Upstream)
Survey Date/Time : 21 July 1994, 1312 to 1610 hours
Acoustic Source : 'Boomer' System operating at 500-2000
Hertz

Water Level Elevation : 447.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #31 cont.				
0290	384857	1290968	26.3	421.2
0140	384596	1290522	23.9	423.6
0143	384295	1290772	22.1	425.4
0150	383975	1291016	21.4	426.1
Survey Line #32				
0160	385112	1290242	28.9	418.6
0163	384812	1290490	26.3	421.2
0170	384511	1290736	24.6	422.9
0173	384195	1290971	22.2	425.3
0180	383890	1291238	20.3	427.2
Survey Line #33				
0183	384819	1290218	26.6	420.9
0190	385385	1289922	37.6	409.9
0193	385326	1290188	29.9	417.6
0200	385031	1290432	29.2	418.3
0203	384726	1290682	25.7	421.8
0210	384410	1290923	22.2	425.3
0213	384103	1291174	18.8	428.7
Survey Line #34				
0223	385269	1290440	30.5	417.0
0230	384955	1290644	27.7	419.8
0233	384660	1290865	26.3	421.2
0240	384357	1291098	24.2	423.3
0243	384052	1291330	21.2	426.3
Survey Line #35				
0250	385505	1290341	33.6	413.9
0253	385187	1290579	31.5	416.0
0260	384880	1290825	24.6	422.9
0263	384568	1291064	23.6	423.9
0270	384250	1291300	23.0	424.5
Survey Line #36				
0280	385482	1290439	34.3	413.2
0283	385177	1290714	27.9	419.6
0290	384857	1290968	26.3	421.2

**Lock and Dam 24
Upper Mississippi River**

Survey Direction: N 50 W (Upstream)
 Survey Date/Time : 21 July 1994, 1312 to 1610 hours
 Acoustic Source : 'Boomer' System operating at 500-2000 Hertz

Water Level Elevation : 447.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #36 cont.				
0293	384528	1291225	23.2	424.3
0300	384560	1291214	23.3	424.2
0303	384221	1291478	24.4	423.1
Survey Line #37				
0313	385442	1290625	31.4	416.1
0320	385130	1290875	28.1	419.4
0323	384806	1291121	25.9	421.6
0330	384481	1291389	24.6	422.9
0333	384148	1291659	28.2	419.3
Survey Line #38				
0340	385623	1290596	30.1	417.4
0343	385322	1290844	29.3	418.2
0350	385013	1291098	23.4	424.1
0353	384704	1291366	24.2	423.3
0360	384370	1291608	26.5	421.0
Survey Line #39				
0370	385490	1290836	29.5	418.0
0373	385192	1291072	27.1	420.4
0380	384889	1291307	24.8	422.7
0383	384584	1291568	26.1	421.4
0390	384246	1291820	27.4	420.1
Survey Line #40				
0393	385687	1290841	28.9	418.6
0400	385343	1291095	29.7	417.8
0403	385008	1291356	27.2	420.3
0410	384677	1291620	25.9	421.6
0413	384341	1291889	24.5	423.0
Survey Line #41				
0420	385780	1290898	30.5	417.0
0423	385399	1291175	28.1	419.4
0430	385047	1291469	25.3	422.2
0433	384697	1291732	24.6	422.9
0440	384342	1292021	21.9	425.6

**Lock and Dam 24
Upper Mississippi River**

Survey Direction : N 40 E
 Survey Date/Time : 21 July 1994, 1628 to 1720 hours
 Acoustic Source : 'Boomer' System operating at 500-2000 Hertz

Water Level Elevation : 447.5 ft MSL (Above the Dam)

<u>File #</u>	<u>Easting</u>	<u>Northing</u>	<u>Water Depth, ft</u>	<u>River Bottom Elevation, ft MSL</u>
Survey Line #76				
0453	383789	1291291	19.9	427.6
0460	384212	1291814	27.1	420.4
Survey Line #75				
0470	384148	1291096	19.3	428.2
0473	384497	1291546	26.7	420.8
0480	384870	1291993	--	---
Survey Line #73				
0503	384217	1290567	20.2	427.3
0510	384581	1291012	24.9	422.6
0513	384920	1291442	26.2	421.3
Survey Line #72				
0483	383998	1290350	19.4	428.1
0490	383537	1290443	--	---
Survey Line #70				
0523	385287	1290602	29.9	417.6
0530	385621	1291041	25.7	421.8
Survey Line #69				
0533	385142	1290173	29.6	417.9
0540	385509	1290568	31.0	416.5
0543	385823	1290976	--	---